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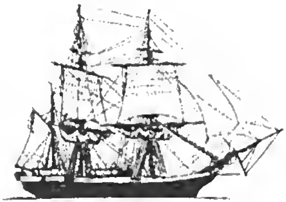

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Volume 13

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CORRIGENDUM

The review of the book by Patricia Grimshaw, Marylin Lake, Ann McGrath, and Marian Quartly, *Creating a Nation* (McPhee Gribble: South Yarra), which appeared in Volume 12: 213-214 was incorrectly attributed to Helen J. Wilson.

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CONTEMPORARY CHANGES IN THE CONSTRUCTION OF A NORTHERN AUSTRALIAN FORM OF SPEARTHROWER.

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ABSTRACT

Contemporary adaptations of traditional items of Australian Aboriginal material culture have been generally neglected as an area worthy of examination in material culture studies. This paper examines the changes that have occurred to the 'gooseneck' spearthrower of northern Australia during the middle part of the 20th century. Formerly the 'gooseneck' spearthrower was a fragile composite implement. Today, however, many are made as relatively robust weapons carved from a single piece of timber. The 'gooseneck' spearthrower appears to be used solely for spear fights within the camp. Contemporary structural modifications displayed in 'gooseneck' spearthrowers may reflect changes in the nature of the rules of combat.

Keywords: Material culture, technological change, 'gooseneck' spearthrower, combat, northern Australia.

INTRODUCTION

There is, within the life of any particular form of artefact, a series of stages through which it is likely to travel. From the moment of either invention or introduction, change and development in mode of construction or materials used in the manufacture of a particular tool type may occur until, for one reason or another, a society no longer requires that implement and it finally disappears from the suite of material items associated with that society. The time element may be of varying magnitude and causes for change may be either environmentally or culturally derived. For example, the hand axe technologies of Africa, western Asia, India and Europe, spanning hundreds of thousands of years, must surely stand as one of the longest sustained technological traditions in human history. The reasons the hand axe was superseded are lost in time, and it cannot be determined whether the change was internally or externally stimulated.

There are, however, instances when the mechanisms of change are not only documented, but their effects can be measured in terms of time and degree. I refer to the changes that one society must go through, when impacted upon by another that not only possesses an ethos of imperialism, but also the material wherewithal to sustain that ethos. I refer of course to the interface between pre-industrial and industrial nations generally, and in this instance to the Aboriginal peoples of Australia and the impact of the European invasion.

There have been numerous studies undertaken on the topic of change and adjustment experienced by Aboriginal peoples in the past. Generally these focus on social and economic issues, with material and technological change being only peripherally dealt with, if referred to at all. There are, of course, exceptions to this broad statement. Sharp (1960: 62-73), in a most important paper examined the impact that the introduction of steel axes had on the internal and external social and economic relations of the Yir Yiront of Cape York. Rose's (1965) work among Aboriginals on a central Australian cattle station is also highly significant for providing insights into the material culture of Aboriginals who were maintaining aspects of traditional life, while integrating into the routines controlled or directed by life in the stock and station camps.

I examined the material culture of the Kimberley region during the 1970s from the perspective of change or modification of traditional artefact forms (Akerman 1979). Changes in the nature of some types of sacred objects found in Western Australia were also examined from the perspective of the construction and maintenance of concepts of 'traditional' in Aboriginal philosophy (Akerman 1995: 43-50).

It is apparent that people in many Aboriginal societies today neither make nor use the articles of material culture that were once indispensable to the lives of their forebears. Other Aboriginal groups may manufacture various elements of the original traditional suite of cultural objects either to maintain a visible link with the past, or to service a rapidly growing market for Aboriginal artefacts. Often, implements that are used in everyday life are modified, sometimes quite subtly, in ways that both the people responsible for their production, and the student that studies them, tend to take for granted. Modifications and changes made two or more generations earlier are now often deemed to be part of the 'traditional' schema of life as practised at the time of first European contact.

There appear to be two broad categories of change that an object may undergo. The first I term 'functionally static changes'. These represent structural variations of the original form that do not alter the purpose or function for which the artefact was constructed. The second broad category of change could be termed 'non-functional adaptations'. Such changes may often be observed when an artefact is created solely for the commercial market with no intention that it would ever serve its 'apparent' real function. A spear, for example, made for sale is rarely made with the same attention to the selection of material, or care and craftsmanship as one made specifically for hunting or fighting. These changes can also occur within a quasi-traditional framework, an example being the spearthrower forms found in the Pilbara and Kimberley now used solely for magical purposes with the spur or hook usually missing (McCourt 1975: 56-57). I have been told by elderly Aboriginal informants that, in the past, the lozenge shaped spearthrowers originating in the Pilbara could also be used by 'clever men' to direct and divert storms and cyclones, as well as for sorcery. As missile launchers they were made obsolete by the adoption of firearms, but retained the necessary attributes that allowed them to serve as vehicles of magic. Non-functional adaptations are evident when comparing cultural objects derived from societies maintaining a traditional or quasi-traditional lifestyle and those cultural objects made for sale and generally available from the plethora of art and craft outlets that have emerged over the past decade or so. The intention of this paper is to detail an example of spearthrower modification that falls into the first, or 'functionally static change', category outlined above.

Spearthrowers, extensively but by no means universally, used by Australian Aboriginals are basically a stick or lath of wood with either an attached spur or hook, or a hook carved in the solid at one end. The spur engages with a concavity in the butt end of the spear and the implement acts as an extension of the arm, increasing the leverage available for propelling the spear. By concentrating virtually all the force of the cast at the base of the spear and directing it along the spear's axis, accuracy can be maintained and the spear projected at a higher velocity than achievable when thrown by the hand alone.

THE GOOSENECK SPEARTHROWER, ITS STRUCTURE AND FUNCTION

I discuss in this paper an unusual form of the stick-like class of spearthrowers which Davidson referred to as the 'gooseneck' type (Davidson 1936: 475-478), and Cundy (1989: 116-119) calls the 'goose spearthrower'. I prefer Davidson's term as being descriptive of the implement form whereas 'goose spearthrower' is ambiguous, intimating (incorrectly) that it was used to hunt these birds. Unless otherwise referenced, the observations presented are based on my own field experiences.

Unlike most other spearthrower forms found among Aboriginal Australians, the gooseneck spearthrower is a relatively flimsy implement that is prone to breakage when under stress. The body consists of a thin (1.5-2.0 cm diameter) rod of light wood averaging about 120 cm in length. At the distal end a small mass of either *Triodia*, *Erythrophleum*, or occasionally *Callitris*, resin is moulded into a blunt hook or spur. About 15-20 cm from the proximal, or grip end, an elongate cone-shaped mass of vegetable resin or wax from the hives of native bees, tapering towards the proximal end, encloses the body (Fig. 1A).

At the time of Davidson's study, the manufacture and use of the gooseneck spearthrower was limited to the north-west quadrant of the Northern Territory and the adjacent Ord River valley in the Kimberleys, Western Australia. Spencer (1914: 378, plate XX) records this type of spearthrower in use among the Kakadu (Gagaju) of the Alligator Rivers area and also illustrates a toy version used by small boys. Basedow (1907: 33-35), writing about the peoples of Darwin and adjacent areas, noted that the main function of this spearthrower was "principally for settling minor quarrels between individuals". Basedow also noted that the proximal end of the spearthrower often served as a drill piece when making fire by friction. In the Forrest River region of the east Kimberley and on the lower reaches of the Victoria River, these spearthrowers were made from the same wood (*Thespesia thespesioides*) as firesticks, and were also used as such when necessary.

Spencer (1928: 823) notes that, among the Kakadu, every male possessed one or more examples of this type of spearthrower, as well as the usual lath-type implement used in day to day hunting activities. This multiplicity of spearthrower forms appears to be the case wherever the gooseneck spearthrower was found, adult males possessing at least two distinct spearthrower types. Among the Aboriginals of the Northern Territory coastal areas, from the Cobourg Peninsula to the Daly River, three types of spearthrowers were in general use, a situation that tends to disagree with the general idea of a minimalist Aboriginal approach to material possessions.

A review of the literature suggests that the gooseneck spearthrower was not introduced into the central and west Kimberley until about 1939. Love (1917), describing Worora material culture, makes no mention of either this type of spearthrower or its associated spears. Elderly Worora and Ngarinyin people in the 1970s said that it was introduced at Kunmunya and Munja settlements in the post-World War II period. In the 1970s it was found throughout the Kimberley but is much rarer today, usually being found in the possession of more conservative elderly males. In the Kimberley, the gooseneck spearthrower is generally known as *warimi* or *warimirri* and the spears associated with it are called *nguni* or *malmurr*. In Aboriginal-English and Creole the spears are generally known as 'bullet' spears, an apt name that reflects the velocity with which they can be hurled.

Bullet spears are small, averaging 1.5 metres in length. The shaft is of light reed, usually *Phragmites* or thin bamboo, and the head is a thin, sharpened rod of hardwood. Ideally, a spear of this type should, in the event of a miss, break on contact with the ground, thus preventing possible re-use by the opposition. Similarly, the hardwood tips should be dry and brittle, enhancing the possibility of shattering in a wound. The preferred woods for the head are thin branches of the grey mangrove (*Avicennia marina)*, ironwood (*Erythrophleum chlorostachys*) or the so called freshwater mangrove (*Barringtonia acutangula*). These woods are all reputed to cause toxic inflammation of wounds. The head usually comprises a quarter to a third of the total length of the spear. Heads may be simply jammed carefully into the hollow internodal area of the shaft or be fixed with a collar of resin or fibre lashing. The base of the spear is cut adjacent to a node, the septal area reinforcing an otherwise fragile zone which will be subject to sudden and intense stress. The spur of the spearthrower will itself abut against the septum and push against it as the spear is being launched.

Lengths of fencing wire may replace wooden spearheads. The base of the wire is often wrapped with a piece of rag prior to being inserted in the shaft, and as the thin smooth wire has a tendency to slip out it is usually bound in position with twine.

When preparing to throw a spear, the hollow base of the spear is engaged with the resin spur. The body of the gooseneck spearthrower is clenched with all fingers into the palm of the hand, and the spear shaft held by the ball of the thumb against the knuckles. The light shaft of the spear may be compressed between spur and fingers, thus bowing it markedly. This action may impart and store energy in the shaft, additional to that provided by the hurling action used in launching the spear. Basedow (1907: 35) illustrates a version of this grip, by which the index finger is extended and not employed at all. These methods of holding spear and thrower appear unique in Australia and are apparently only used with this type of spearthrower.

My concern here, however, is with the number of structural variations this spearthrower type has undergone in the recent past. According to information which I have gathered from Aboriginal peoples across the area in which the gooseneck spearthrower is found, most of these modifications and variations have emerged over the past thirty or forty years. All the variations described below are regarded by their makers or users as *warimi* or *warimirri* and all were made for use with bullet spears in settling camp disputes. None were made for sale. Indeed, they rarely appear in art and craft outlets even when present in numbers within a community. It should be stressed here that no chronological order is imputed in discussing these variations.

TECHNOLOGICAL CHANGE AND THE GOOSENECK SPEARTHROWER

The first modification dispenses with the wax or resin cone that would normally be placed at the proximal end. This cone is not a grip, but rather a stop against which the hand can be buttressed. To compensate for the loss of this feature, the proximal end of the spearthrower is slightly enlarged and the body then tapers back to the distal end furnished with the resin spur (Fig. 1B).

In the second variation, the resin spur is replaced with one made from wood. This may be attached in either of two ways. The spur can be made along the lines of the those used with the conventional Kimberley - northwestern Northern Territory spearthrowers (Davidson 1936: 472, fig 6c), requiring a Y-shaped section of tough wood, one arm of which is markedly thinner than the other. The thin arm is placed through a hole bored through the distal end of the spearthrower and wet sinew is then used to lash it in place. The base of the Y projects up and forward and it is on this that the spear will be engaged. When the sinew has dried, the spur is further refined and trimmed and the projecting arm that pierces the body is cut flush with the binding. Finally, the whole distal end, apart from the projecting base of the Y, is enclosed in either *Triodia* or *Erythrophleum* resin. The tip of the spur that engages the spear is normally broad and blunt (Fig. 1C).

Alternatively, the spur may consist of a slightly curved piece of wood flattened at one end of the convex side. This flattened area is placed against the body of the implement and directly bound to it (Fig. 1D). This is similar to the Western Desert method of mounting spearthrower spurs as described by Thomson (1964: 415). Unlike the spurs on desert spearthrowers however, those used on gooseneck spearthrowers are not sharply pointed. All spurs are relatively broad and blunt, a feature that ensures that the reed or bamboo shaft can cup the spur without enclosing it totally. A sharp spur enclosed by the reed shaft and abutting against the septum could pierce the latter or otherwise damage the fragile spear butt. It should be remembered that there are at least five other methods of mounting spearthrower spurs used in Australia. In the Pilbara, Murchison and the south-west of Western Australia, the spur may be fixed to the body of the spearthrower with resin prior to applying the sinew lashing, and resin also is used to cover the lashing. Across Arnhem Land and on Groote Eylandt the spur is slotted into a carefully carved notch or fork at the distal end of the implement and then lashed on with resin covering the binding (Hale and Tindale 1925: 98). Roth (1909: 198, Plate LVII, nos. 10-14) provides descriptions of three methods of mounting spearthrower spurs as practised on Cape York, Queensland. Neither Davidson (1936) nor Cundy (1989) discuss spur mounting techniques in their surveys of Australian spearthrowers.

The original form of gooseneck spearthrower and the three variations are probably all equally as common today and comprise about 90% of the sample observed. The fourth and final variation, whilst not common, has been sighted by me in the Kimberley and the adjacent Northern Territory at least a dozen or so times over the past twenty years. Examples said to have been made at Port Keats have been collected as far south as Elliott in central Australia (W. Murgatroyd pers. comm.).This version of the gooseneck faithfully copies the form of the composite original, the whole being carved in the solid from a single piece of wood. The stop and spur are faithfully sculpted, duplicating the resin elements, and the whole implement is structurally much sounder than the forms described above. Occasionally the stop is ring -, rather than cone - shaped (Fig. 1E).

The fact that the latest version of the gooseneck spearthrower is stronger than the earlier models may well reflect breakdowns in the organization of behaviour in conflict situations. The traditional prototype and the resin-spurred variant are fragile pieces of equipment. The caution required in their use may have engendered enough restraint to take some of the edge from passions embroiled in the heat of conflict. Without care, too great a force could cause the resin hooks to fragment, an inbuilt flaw that could force an element of constraint (albeit slight)

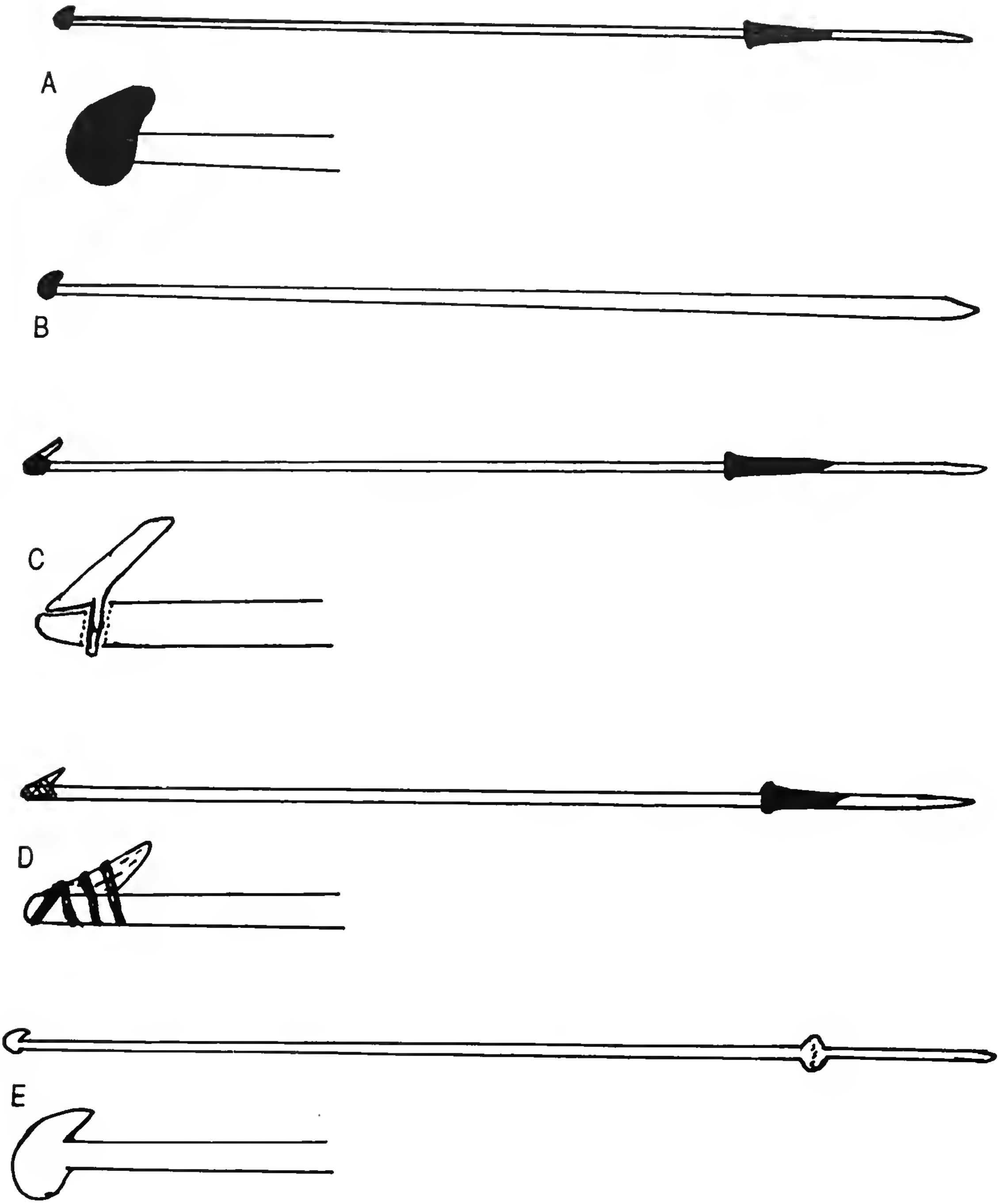

Fig. 1. A, composite gooseneck spearthrower - the original form with hard resin hook or spur (see enlargement) and wax or resin grip-stop. **B**, modification 1. The resin grip stop has been dispensed with and the proximal end has been expanded. **C**, modification 2a. The resin spur has been dispensed with and replaced with a wooden spur of the northern or Kimberley form. The sinew lashings and resin that cover the union are omitted in the enlargement in order to illustrate how the junction is effected. **D**, modification 2b. The resin spur has been dispensed with and replaced with a wooden spur of the desert form. A resin coating over the sinew lashing may be applied at the discretion of the maker or owner (see enlargement). E, modification 3. Gooseneck spearthrower carved in the solid, imitating the composite prototype. The enlargement illustrates how faithfully the form of the spur resembles the original waxen form as shown in A.

into a conflict situation. It is possible that we are seeing, in the original form, a device ostensibly produced as a weapon launcher, but in fact developed to assist in the maintenance and control of 'conflict ritual'. The very fragile, sabre-like, *palati* spearthrower of the north-west Northern Territory possibly served the same function. Spencer (1928: 822) gives the dimensions of a Kakadu *palati* as four feet (122 cm) long by two and five eighths inches (5.7 cm) wide yet only three sixteenths of an inch (47 mm) thick. These spearthrowers were rare and could only be used by the most skilful and experienced men (Spencer 1928: 823; Basedow 1907: 35).

The modified types of gooseneck spearthrowers with attached wooden spurs and a solid form now permit spears to be thrown with greater force without suffering structural failure. As spear fights (at least those that I have witnessed) tend to erupt abruptly (with minimal ritualization) as a verbal dispute escalates, the caution inherent with the use of the fragile composite spearthrower need no longer be exercised.

It should be stressed that the traditional lath-type spearthrowers of the Kimberley are no longer made and used for hunting and fighting. Those that are made are generally produced for the art and craft market, although some may be injected into the indigenous exchange systems that continue to operate today. Older, more conservative men may make and store a gooseneck spearthrower and a bundle of bullet spears in their homes, on the off-chance they may be required in the event of conflict.

Although the changes that the gooseneck spearthrower has undergone are interesting in their own right; a far more intriguing question is, why have these changes occurred?

CONCLUDING REMARKS

The original form of the gooseneck spearthrower is unique in its structure and specific in its function. The modified forms exhibit a varying combination of the structural features associated with both the original form, and also of other spearthrower types found in the region. The function of the modified forms remains the same as that of the original - to launch spears in conflict situations. There has been no substitution of the traditional materials used in the construction of the spearthrower by introduced exotic materials, and the changes in form do not reflect a change or loss of primary function that are often evident in artefacts made for commercial purposes (Akerman 1969: 243, 250-251). What has been lost however, is the element of restraint or control, forced on the protagonists by the very fragility of the resin-spurred prototype.

It appears that the variations have occurred as individual expressions of a mental template or attribute list. Perhaps one could say that the gooseneck spearthrower template has, itself, been refined to its barest essentials, ignoring extraneous materials and traditional modes of construction. Thus the attributes of the contemporary template consists of the following.

1) A light thin rod shaft, that allows maximum rapid motion with minimum air resistance when swung. Flexibility of the shaft may also be of importance when casting the spear.

2) A spur or hook to engage the spear.

3) A stop at the proximal end to buttress the hand and ensure a firm grip.

How the above criteria are met is today immaterial. Experimentation, as evidenced by the variations discussed, has demonstrated that there are alternative possibilities to those manifest in the original template that suffice equally as well in fulfilling the original function of hurling short, sharp spears with considerable force at someone who is likewise engaged. With the adoption of the solid gooseneck spearthrower, there is increased likelihood of an engagement escalating, perhaps with more serious consequences than may have occurred with the resin spurred model. As such we are looking at an item of material culture that reflects a change in one aspect of the social mores relating to conflict that has occurred in some Aboriginal societies.

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THE LATE MIOCENE ONGEVA LOCAL FAUNA OF CENTRAL AUSTRALIA.

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ABSTRACT

The late Miocene Ongeva Local Fauna (LF), comprising vertebrate remains derived from channel sands in the Waite Formation (Alcoota Station, central Australia), probably resulted from natural attrition around permanent or semi-permanent pools in seasonally flowing streams. Mortality due to prolonged drought, such as that postulated for the stratigraphically lower Alcoota LF, is not indicated. Strata hosting the Ongeva LF show more proximal fluvial characteristics than those hosting the Alcoota LF. Coarsening upwards in the section may be related to tectonism or climate change. New material of *Kolopsis yperus* Murray, Megirian and Wells (Zygomaturinae) makes more likely the possibility of its synonymy with *Zygomaturus gilli* Stirton (Cheltenhamian Stage of Victoria). Hypotheses of the phylogenetic position of these taxa within the Zygomaturinae seem reasonably stable, but it is observed that current taxonomy does not satisfactorily codify what is known of zygomaturine evolution. The Ongeva LF also contains *Kolopsis torus* Woodburne (previously known only from the Alcoota LF) and an undetermined species of the crocodylid genus, *Quinkana* Molnar.

Keywords: Miocene, vertebrate palaeontology, Waite Formation, central Australia, Ongeva Local Fauna.

INTRODUCTION

Murray, Megirian and Wells (1993) provided the initial description and definition of the late Miocene Ongeva Local Fauna (LF) from Alcoota Station, central Australia, outlining its stratigraphic setting and biochronological significance of the zygomaturine diprotodontid *Kolopsis yperus*. Other components of the fauna were listed, but not described. Here we describe additional specimens of *K. yperus*, confirm the presence of *Kolopsis torus* Woodburne, and describe material referrable to the crocodylid *Quinkana* Molnar.

The accumulated sample of *K. yperus* upper third premolars morphologically encompass *Zygomaturus gilli* Stirton, raising the possibility of synonymy. However, an informative upper first molar of *Z. gilli*, important for establishing or refuting conspecificity with *K. yperus*, is lacking. The systematic position of these taxa within the Zygomaturinae, and taxonomic implications, are considered. A major component of the Local Fauna, the giant, flightless birds of the family Dromornithidae, are reserved for a future paper, but preliminary analyses suggest continuity with Alcoota LF taxa in the form of a *Dromornis* sp. cf. *stirtoni* and an *Ilbandornis* sp.

Although the accumulated Ongeva LF sample is small, and taxonomic work is incomplete, five years of collection has produced sufficient data to establish the general nature of the assemblage, which can now be compared with that of the underlying Alcoota Local Fauna. Observations of the stratigraphy and sedimentology of the Waite Formation in its type area are related to the regionally-focussed investigations by Senior *et al.* (1995) of the Tertiary intermontane basins of central Australia.

In Murray *et al.* (1993) we used the dental terminology of Archer (1978), under which diprotodontid cheekteeth are designated P3, M2 - M5. Here we revert to the older convention of P3, M1 - M4. A second Ongeva quarry was opened after the drafting of Murray *et al.* (1993). The original quarry on the north side of Hill 1 featured is Murray *et al.* (1993) is now distinguished as the 'Type Quarry', and the newer one on the opposite side of the hill is referred to as the 'South Quarry'.

Abbreviations. NTM, Northern Territory Museum; SGM, Spencer and Gillen Museum (now Museum of Central Australia), Alice Springs, Northern Territory. It is implicit where no institutional prefix is given that the material is lodged with NTM. TS refers to petrographic thin-sections at NTM.

STRATIGRAPHY, SEDIMENTOLOGY AND TAPHONOMY

Geological setting. The Waite Basin (Fig. 1) is one of many generally elongate structures filled with Cainozoic sediments within and surrounding the crystalline, Early to Late Proterozoic Arunta Block. The formations within these basins are broadly similar in their sedimentology, stratigraphy and alteration by weathering events, reflecting a similar geological history (Senior *et al.* 1995).

In general terms, a deep weathering event in the late Cretaceous was followed by a long period of predominantly lacustrine sedimentation lasting into the late Eocene. Two episodes of deep weathering affected these early Tertiary sediments, one in the pre mid-Eocene, and one in the late Eocene. There are also weak indications of the late Oligocene deep weathering event that affected adjacent parts of the continent, but otherwise non-deposition characterised the late Eocene to early Miocene, when predominantly fluviatile sedimentation commenced. Shifts in the drainage systems in the Oligocene or early Miocene were possibly due to uplift related to compressional tectonics resulting from the collision of the Australian and Pacific plates in the New Guinea region. This may account for the absence of a well-developed late Oligocene weathered profile in the region. The early Miocene to Holocene record is characterised by discontinuous fluviatile sedimentation, interspersed with more localised erosional

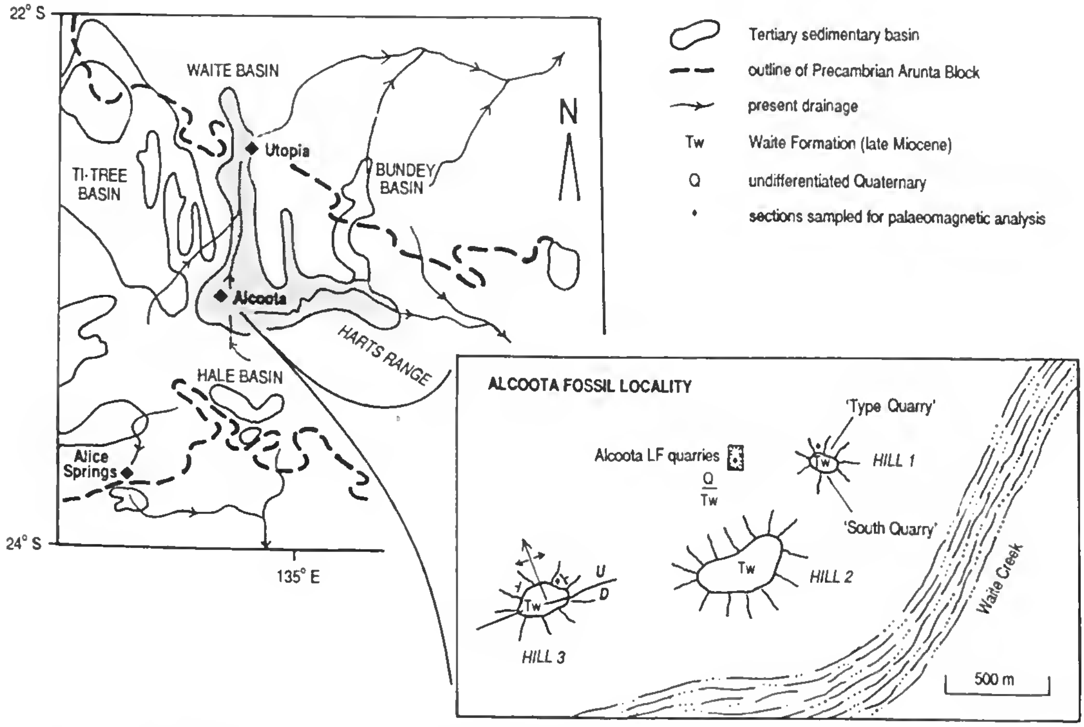

Fig. 1. Locality diagram after Senior *et al.* (1995: fig. 1) and Woodburne (1967a: fig. 2).

and weathering phases. There is also evidence of stream rejuvenation and changes in drainage patterns possibly related to minor tectonism. The later part of the sedimentary record (latest Pliocene onwards) contains aeolian sediments.

Sediments filling the Waite Basin are known informally as the Alcoota beds: those exposed in outcrop were formalised as the Waite Formation by Woodburne (1967a) (Senior *et al.* 1995). The composite thickness of the Alcoota beds is inferred to be about 250 m. The Waite Formation accounts for about 44 m, or 15%, of the Alcoota beds. It crops out at the southern periphery of the basin as interbedded chalcedonic calcarenitic limestone, sandstone, siltstone, and minor sandy conglomerate, and shows an overall pattern of coarsening upwards. The Waite Formation contrasts with the argillaceous Alcoota beds encountered in drill holes. Only a few metres of finer Alcoota beds, attributed to lacustrine sedimentation, are exposed as Waite Formation.

Stratigraphy. Quarrying on the north and south sides of Hill 1 between 1992 and 1995 provided better exposures of the stratigraphic succession hosting the Ongeva Local Fauna than were available to Murray *et al.* (1993), permitting some additional differention of sedimentary units. The elaboration presented below does not change the substance of the biochronological or biostratigraphic relationships of the Alcoota and Ongeva Local Faunas presented in Murray *et al.* (1993). To aid description, five informal lithostratigraphic members are recognised on Hill 1, designated I to V.

The stratigraphy of the South Quarry is shown in Figure 2. At the base is a pisolitic unit (I), which forms the floor of the quarry. Ferrugi-

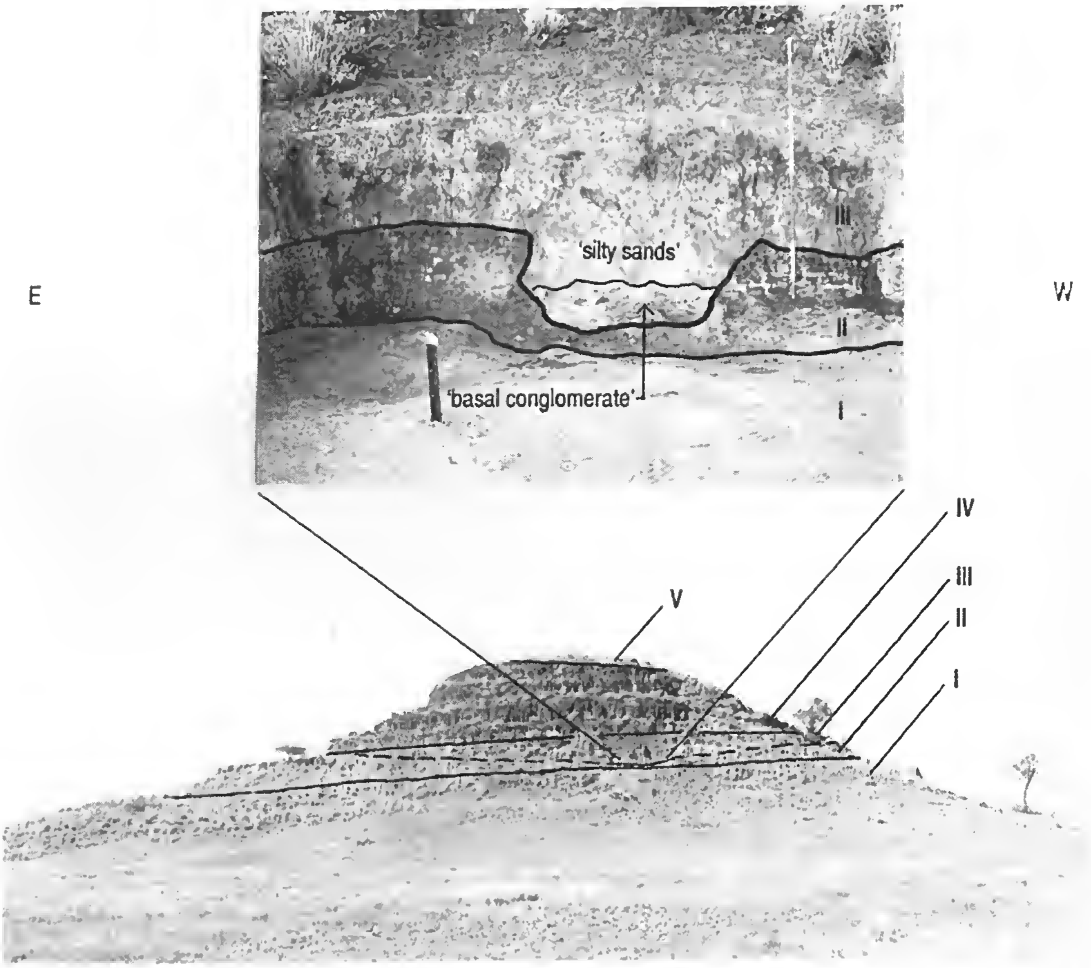

Fig. 2. Hill 1 from the south, and stratigraphy in the 'South Quarry', July, 1995. Divisions on the stadia rod in the quarry are 0.5 m. The hillslope above the 1.5 m mark on the stadia rod has been cleared of loose boulders and benched. Informal members I - V as described in the text.

nous pisolites and their sandy silt matrix are cemented by diagenetic calcite to form a competent rock (Fig. 3A, B). This unit, described more fully in Murray *et al.* (1993), represents an ancient weathered profile, and its surface is the major unconformity separating strata hosting the Ongeva and Alcoota Local Faunas.

The pisolitic unit is succeeded in sharp, but irregular, contact by an unfossiliferous ferruginised and calcified unit, which in textural terms is a poorly sorted, silty sandstone (II) (Fig. 3A). The coarse fraction consists mostly of quartz, with ironstone and other lithic grains comprising a minor component, set in a ferruginous matrix. The grains range from sub-angular to rounded. No sedimentary structures are evident. Within the quarry, the unit has a massive appearance, due to the fairly homogenous degree of iron induration, but the distribution of the coarse clastic fraction varies laterally and vertically. The ferruginisation is attributable to both staining of finer clastic particles (silt size) and ferruginous cement, which together form the matrix of the unit. Diagenetic sparry calcite

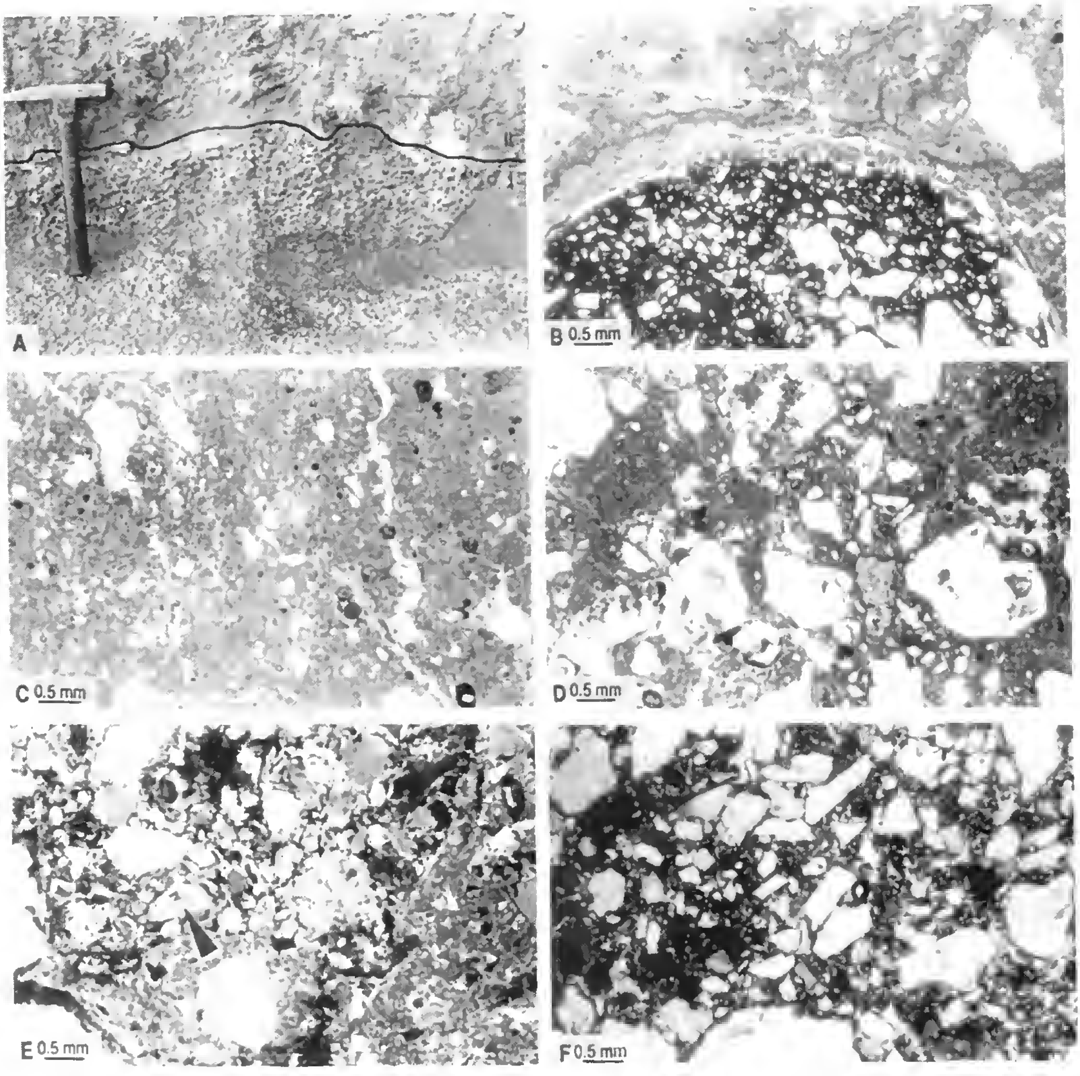

Fig. 3. A, contact (enhanced) between the pisolitic unit (I) and the ferruginous sandstone (unit II), western face of the South Quarry, July 1995; **B**, photomicrograph of a ferruginous pisolite in sandy silt matrix (unit I). Circumgranular fractures are filled with sparry calcite cement and quartz grains in the matrix are etched, common features in caliche profiles; **C**, photomicrograph of sandy silt bed (unit III), Type Quarry; **D**, photomicrograph of silty sand (unit III), Type Quarry; **E**, photomicrograph of silty sand with bone shards (unit III), South Quarry; **F**, photomicrograph of red sandstone (unit IV). B, C, D and F in plane polarised light; E crossed polars.

is also present in veins. Along strike, outside the quarry to the west and around to the opposite side of the hill, weathered outcrop is much lighter in colour (very pale orange). The unit was probably initially deposited as poorly sorted silty sandstone, similar to those comprising higher units on Hill 1, diagenetically altered to a duricrust (ferricrete / calcrete) during an episode, or episodes, of sub-aerial exposure. Additional evidence for a hiatus comes from the erosional unconformity with the succeeding fossiliferous (Ongeva Local Fauna) sediments (III).

In the South Quarry, the Ongeva Local Fauna beds (III) are confined at their base to a narrow, steep-sided channel, about 1.5 m wide and 0.5 m deep (Fig. 2). The western bank of the channel is undercut, while the eastern bank has an apparent slope of about 60°. The steep bank profiles indicate that the fossiliferous beds were deposited over a unit already stabilised to a high degree of mechanical competence before channel incision. The base of the channel contains a 10 to 20 cm thick conglomerate, composed of pebble- to cobble-sized crystalline metamorphics, vein quartz, ferricrete clasts, cream to pale greeen calcareous siltstone and sandstone, ferruginous pisolites, and vertebrate fossils (described separately below). Interstices between the large clasts are filled with white to pale green calcareous siltstone, with some primary intergranular porosity filled with diagenetic coarse, sparry calcite cement. The crystalline igneous and metamorphic rocks were derived from the basement complex of the Waite Basin, the ferricrete clasts and pisolites probably reworked from the two underlying units (I and II), and the calcareous lithoclasts are probably intraformational reworkings (i.e. lithofacies of unit III).

The basal conglomerate of unit III is succeeded by poorly indurated, pale greenish yellow, bedded, silty sand (Fig. 3E). The higher exposures of the unit in the South Quarry are affected by ferruginous mottling, which penetrates with decreasing intensity to about 1.5 m below the present land surface. Un-mottled material was only intersected at the back of the quarry (Fig. 2). Faintly visible through the mottling are bedding traces. The lowest bed fills the channel and extends over the banks, reaching a maximum thickness of about 1.2 m over the basal conglomerate. The succeeding beds are thinner (20 - 30 cm). The top of the unit and its contact with the overlying, dark red, unfossiliferous conglomeratic sandstones (IV) is not clearly exposed, but the maximum thickness of the fossiliferous unit is in the order of 2 m. The sand and grit fraction consists of angular to rounded quartz, crystalline lithic grains and minor plagioclase. Excluding the large bones and bone fragments, the lowest bed is significantly bioclastic, containing bone shards up to 10 mm long. The distribution of these is variable in the quarry, from being a trace component up to an estimated 5% of the volume. The bone shards, especially ones composed of compact bone, resemble fragments resulting from sub-aerial weathering after the collagen is broken down.

The unfossiliferous red silty sandstones and minor interbedded conglomerates (IV) of Hill 1 are composed of poorly sorted angular quartz, lithic grains, plagioclase and microcline feldspars, and weathered mica (?muscovite) (Fig. 3E). They contain less fines, and are indurated to a greater degree than the underlying beds, which together with their compositional and textural immaturity, reflect a change in the sedimentological regime. The contact between units III and IV coincides with Woodburne's (1967a) subdivision of the Waite Formation into two (informal) members, the lower 'lacustrine beds' and the upper 'fluviatile beds'. The top of Hill 1 is occupied by residual boulders of chalcedony (V), the last remnants of a bed of pedogenic limestone, as described in Woodburne (1967a).

The stratigraphy within the Type Quarry is similar to that in the South Quarry, differing only in that within unit III, the basal conglomerate and silty sandstones are separated by a thin (c. 20 cm) unit of sandy silt (Figs 3C, 4). This may be equivalent, at least in part, to the matrix of the conglomerate in the South Quarry. The contact between the silty bed and the superposed coarser lithologies (Fig. 3D) is distinct, but irregular. The fossiliferous sediments are not as confined as they are in the South Quarry. The western bank of the channel is lower and more gently inclined than on the opposite side of the hill. The eastern bank remains hidden below scree, so that the full width of the channel cannot yet be determined. However, it is greater, though perhaps not much more so, than the 8 m width exposed in the quarry: the lenses of channel-fill, evident through the mottling, are lowest mid-way along the quarry face (Fig. 4).

The sandstone (II) into which the Ongeva Local Fauna beds are incised was not inter-

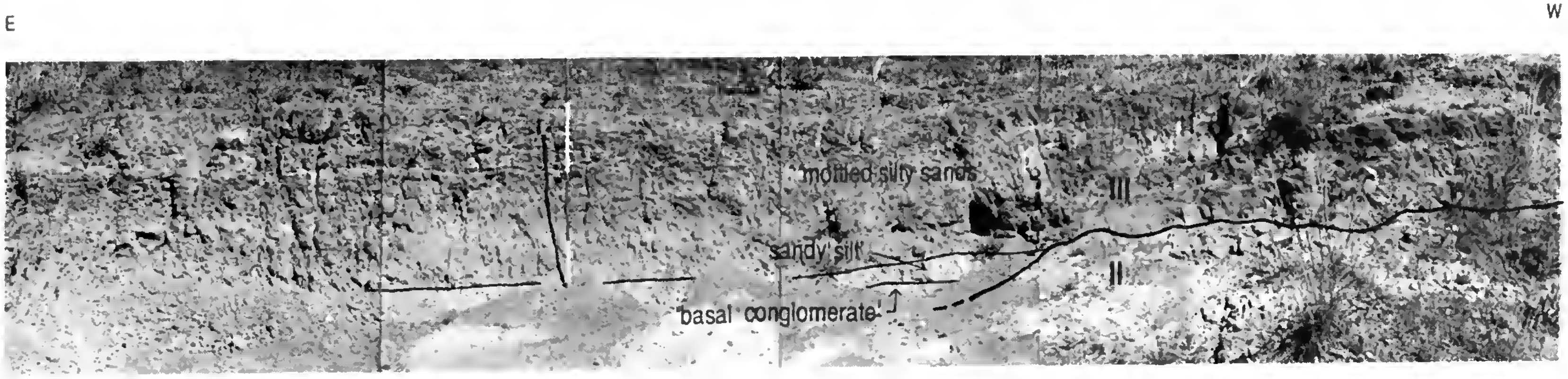

Fig. 4. Photomosaic of the Ongeval LF 'Type Quarry' (July, 1995 - the quarry was last worked in July, 1994). Colluvium shed from the quarry face in the year preceding photography obscures most of the 'basal conglomerate' and 'sandy silt' of unit III, which terminate against unit II at the western edge of the quarry. Lenses of silty sand (III) are discernible through mottling. Divisions on the stadia rod are 0.5 m. The hillslope above the quarry (above the 1.5 m level on the stadia rod) has been cleared of loose boulders and benched.

sected in the section logged by Murray *et al.* (1993: fig. 2), a few metres east of what is now recognised as the western bank of the channel. The appearance in outcrop of these two sedimentary units differs from their exposures below the zone of weathering apparently related to the present land surface. This current phase of weathering has resulted in the mottling of unit II and a lightening in colour of unit III, which might be due either to surficial leaching of iron, or more likely, a lighter overprint of calcrete. Consequently, the two units have a similar appearance in outcrop and shallow subcrop. Because of this similarity, coupled with inadequate exposure, Murray *et al.* (1993: 158) interpreted the silty bed of unit III as being continuous with what is here differentiated as unit II:

> .. the contact between the two [the sandy silt bed and the lowest silty sand bed of unit III] is irregular, and where it can be traced from the [Type] quarry along strike to a point about 10 m to the west, has a relief of about 0.8 m.

The margin of the Type Quarry was then a few metres east of its position in 1994/95, but as Figure 4 shows, while the contact between sandy silt and the silty sand beds is irregular, the sandy silt terminates in the channel against unit II, and its contact with the silty sand has no such relief. Woodburne's (1967a) description of his member 5 in the Hill 1 section appears to include attributes of both units II and III. He measured his section on the southwestern face of the hill (where unit II crops out), but noted that 'sparse fossils (occur) as weathered fragments in more reduced pockets .... on the northwest face of the hill' (Woodburne 1967a: 175).

The fossiliferous beds (III), being notably less indurated, weather recessively and are almost entirely covered by scree, while the duricrusted host sandstone (II) crops out as a resistant ledge at the eastern end of Hill 1, as does the underlying pisolitic unit (I) (Fig. 2). The sharp and irregular contact, and the lithological differences, indicate that unit II is not genetically related to the pisolitic unit (I). Unit II was deposited unconformably on Unit I, and then duricrusted during a phase or phases of subaerial exposure, the effects of which may have penetrated into unit I, overprinting earlier diagenesis. The stratigraphy of Hill 1 is summarised in Figure 5. The interpretation of two palaeo-surfaces between Alcoota and Ongeva Local Fauna times merely reinforces the chronostratigraphic separation of the two assemblages.

No sedimentary structures were observed in unit III in either quarry that indicates the direction of sediment transport. The similar north-south channel alignments observed in both quarries, similar base level, and approximately 40 m horizontal separation, indicates that the same channel or confluent channels are intersected in the two quarries. The contrasting cross-sectional proportions, narrow and deep in the South Quarry, and shallow and wide in the Type Quarry, suggests that across the width of Hill 1, the palaeohydraulic gradient was from south to north.

In an endeavour to more completely characterise the stratigraphy, and perhaps even the age, of the Waite Formation in the Alcoota area, Hill 1, Hill 3, and the strata exposed in the Alcoota Local Fauna quarries, were sampled during 1992 for palaeomagnetic analysis (Fig.1). The type section of the formation at Hill 2 was not selected because weathering is deeper and more advanced than in other sections, and consequently offered weaker prospects for useful results. Samples were subjected to comprehensive alternating field (AF) and thermal demagnetisation. Demagnetisation quality was poor, and the results disappointing. All three sections sampled are dominated by normal magnetic polarities, with recorded NRM (Natural Remanent Magnetisation) intensities correlated to increased red (iron oxide) pigmentation up-section. It thus seems likely that the normal polarity directions are pedogenic overprints, rather than primary (M. Whitelaw, University of Texas, written communications, 20 March and 28 April, 1994).

Some of the beds sampled for palaeomagnetic analysis at Hill 3 dip at angles as high as 13° to the northeast. While the beds are lenticular, the unit which they comprise ('fluviatile beds' of Woodburne 1967a) was traced in outcrop to the west, where beds dip northwest, though at lower angles (2-4°). It is difficult to attribute the divergent angles of dip to deposition. The observed attitudes of bedding at Hill 3 are consistent with a small anticlinal structure plunging to the north, with an axial plane dipping at a high angle to the west. The structure is exposed on the upthrown side of an east-west trending fault recorded by Woodburne (1967a) (Fig.1).

Taphonomy. No marked differences were noted in the palaeontology of the two Ongeva

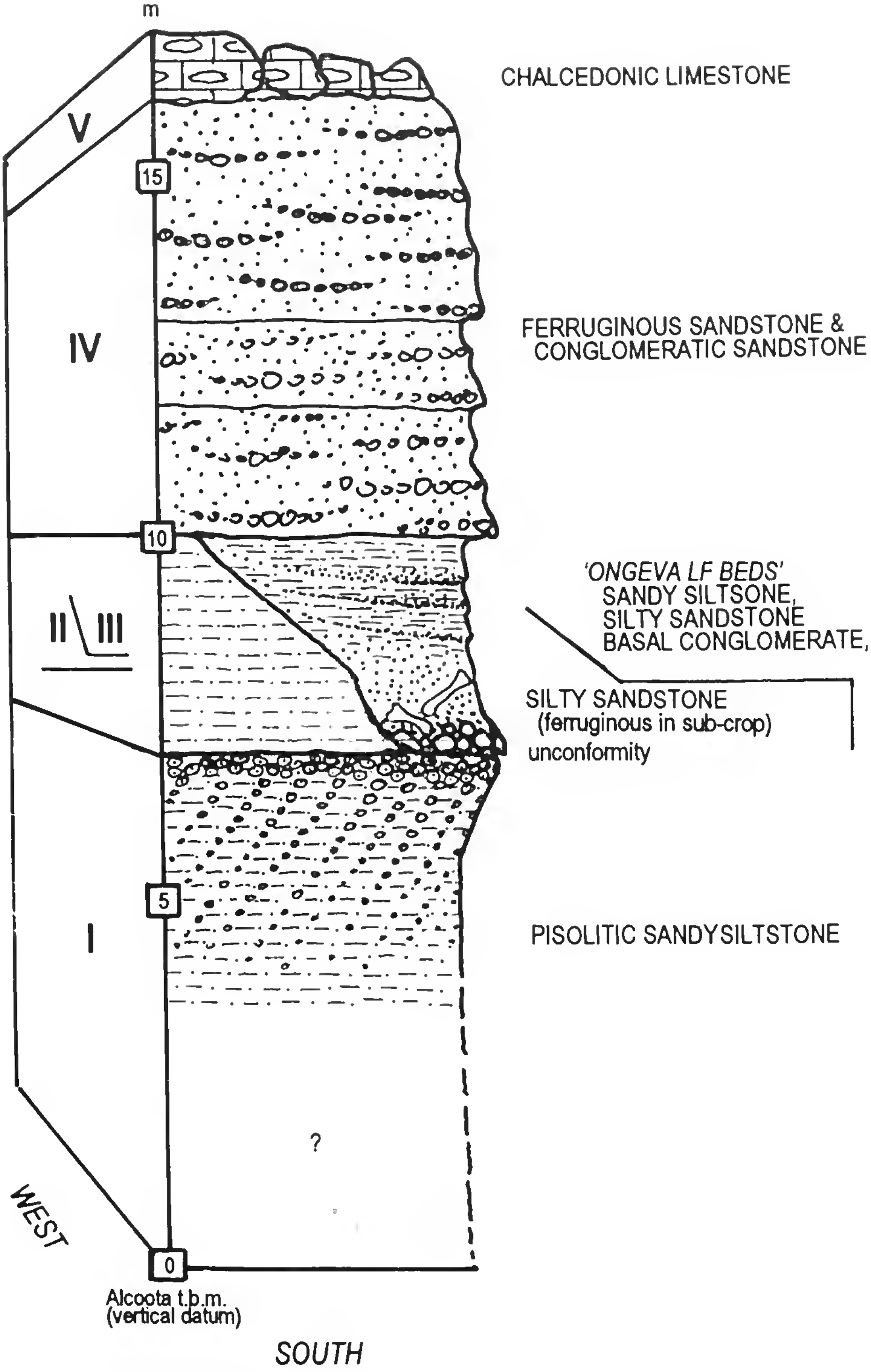

Fig. 5. Schematic diagram of the Waite Formation stratigraphy at Hill 1.

LF quarries. Due to the generally fragile condition of the fossils, not all specimens could be successfully extracted.

Remains of several species of large flightless birds (Dromornithidae) and large herbivorous marsupials (Zygomaturinae) predominate in the basal conglomerate (Fig. 6A). The dromornithids are mostly represented by the shafts of long bones (especially tibiotarsi and tarsometatarsi, less frequently femora). The long bones lie horizontally or sub-horizontally, aligned parallel or at low angles to the channel margins. Pes elements and other post-cranials, and cranial fragments are infrequent. Zygomaturinae are represented predominantly by disarticulated maxillae, horizontal rami of dentaries and long bones (usually with damaged ends). Other cranial and post-cranial fragments are less frequent. Ribs of the large avian and marsupial herbivores are represented only by short fragments. Fragmentary crocodile remains, and postcranials (mostly manus and pes elements) of a small macropodid (cf. *Dorcopsoides*) contribute to the smaller size fraction. Fossils from the basal conglomerate are typically well mineralised.

Fossils from the silty sand and sandy silt are similar in their taxonomy and representation, differing only in the following respects: broken edges of bones are generally less rounded and in some cases sharp; depositional orientations of long bones are random (some vertical); and few fragile skeletal elements are preserved. The lower beds have a greater concentration of bones than the higher beds, but more complete specimens occur at a higher frequency up-section. Mineralisation is generally poor, with the exception of the few collected from high in the mottled zone, where diagenetic emplacement of iron and possibly magnesium oxides has toughened them to a high degree.

In the 'Type Quarry', two coprolites (P9271, P9413) were found deposited directly upon bones embedded in the basal conglomerate. Both coprolites resemble Recent cow pats in their size and gross morphology (Fig. 6B). Preservation is attributable to calcification. In sawn transverse section, P9413 is irregularly laminated

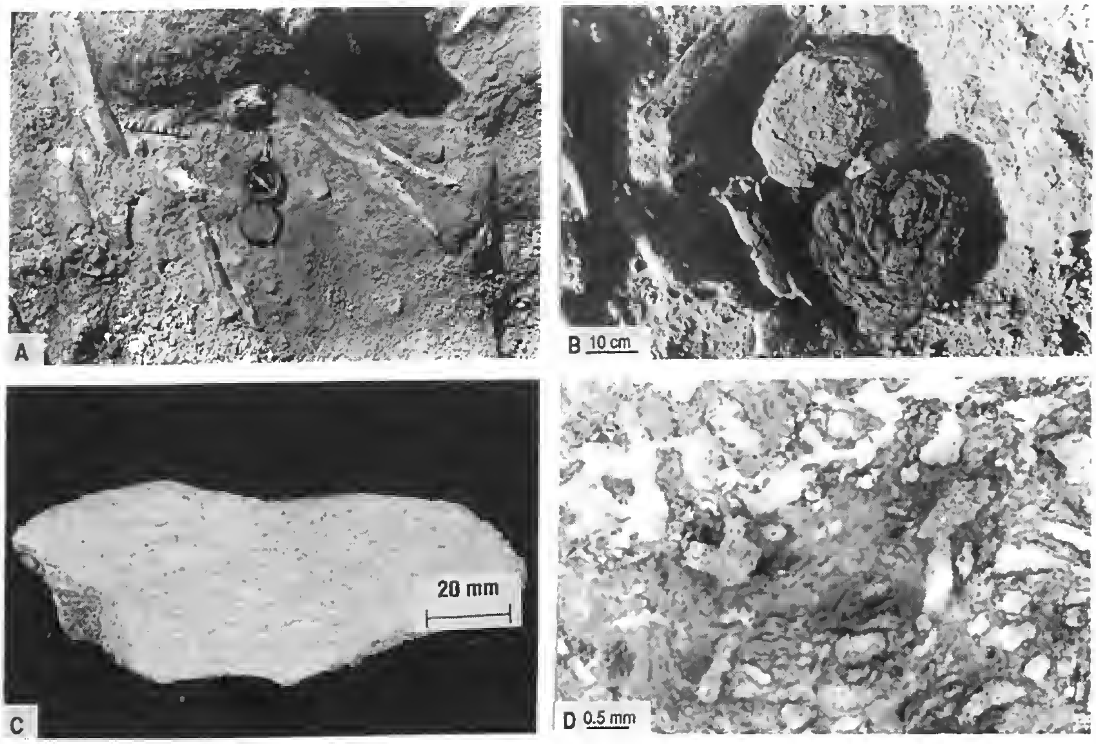

Fig. 6. A, four dromornithid long bones, from left to right, cf. *Dromornis* femur and tibiatarsus, cf. *Ilbandornis* tibiatarsis, and cf. *Dromornis* tibiatarsus, all lacking ends and showing a preferential alignment to the channel margins as indicated by the compass, in the basal conglomerate of the South Quarry. The tooth row of *K. yperus* (P961) is exposed in the centre of the upper right quadrant; B, a coprolite (P9271), *in situ* in the 'Type Quarry' (July 1992), with a Recent cowpat (bottom centre) for comparison; C, transverse slab through coprolite P9413; D, photomicrograph (TS 0084) of coprolite P9413 in plane polarised light.

(Fig. 6C). Thin sections (Fig. 6D) show alveolar to clotted texture. Fabric elements include microspar, tubular root moulds, peloids, glaebules defined by circumgranular fractures, and clay cutans. Fractures and root moulds are filled with sparry calcite cement, though in some instances, geopetal carbonate silt occupies the lower part of voids. There are also signs of incipient silicification as chalcedony. Many of these internal features are characteristic, and some diagnostic, of caliche (e.g. Estaban and Klappa 1983). Post-depositional processes in an environment conducive to pedogenic carbonate emplacement thus appears to have both fossilised the coprolites and completely obliterated original internal structures and fabrics, leaving no clues as to the plant matter that was consumed by the animals leaving these traces, or its state after digestion, though it was most probably very finely divided.

Thus, remains of dead animals accumulated, most likely by natural attrition, within the catchment of a small, probably ephemeral stream. Only the larger and most robust skeletal elements became preserved locally as components of the channel lag (basal conglomerate). The remainder were swept downstream, to be deposited at some unknown location. The length of time over which these typically eroded fossils, representing a highly winnowed fraction, were accumulated is unknown, but perhaps over a considerable period, during which they became both (syndepositionally) mineralised and cemented into place.

A transition in sedimentological regime is indicated by the channel filling sediments. Deposition of the lowest Ongeva LF bed, a sandy silt restricted to the downstream segment of the channel, buried the coprolites deposited by large herbivores without displacing them. A subsequent, more energetic event mobilised large amounts of sediment and the skeletal remains which had accumulated, still by natural attrition, within the catchment. Some bones had laid on the surface for some time before transportation, extended sub-aerial exposure permitting both scavenging, disassociation, trampling, and physico-chemical denaturing and disintegration of the bones. The detritus was swept into the channel and deposited as poorly sorted silty sand, incorporating large bones and bone fragments in random orientations. The high sediment load limited the capacity of the stream to deeply scour and rework the underlying sandy silt, or to sort its load.

The channel continued to aggrade with similar deposits, but these depositional events occurred with a frequency that allowed little time for skeletal elements to accumulate in the catchment, as evidenced by the decreasing frequency of vertebrate fossils, but generally more complete specimens, up-section.

SYSTEMATIC PALAEONTOLOGY

Diprotodontidae Gill
Zygomaturinae Stirton, Woodburne and Plane
Kolopsis torus Woodburne, 1967b

(Tables 1-3)

Referred material. P92152, right dentary; P92153, left dentary; P92178, right dentary; P92147, edentulous right maxilla; P9216, left and right maxilla; P967, left dentary M_{2-5}; P968, right dentary M_{2-5}; P969 left dentary M_{2-5}; P9610, left premaxilla and maxilla, I^1, P^3, M^{2-5}; P9216, left and right maxillae.

Description. The Ongeva *Kolopsis torus* material, in so far as it is represented, conforms to the original diagnosis of the Alcoota Local Fauna sample of the species (Woodburne 1967a,b) and does not require additional description. A few measurements of the teeth fall outside the range of the Alcoota sample (Tables 1-2).

Comparative remarks. The Ongeva *Kolopsis torus* sample is structurally indistinguishable from the Alcoota sample, but shows some slight morphometric differences in the teeth. The small Ongeva sample size precludes any meaningful statistical comparisons with the Alcoota population, but we observe that the differences are probably no greater than those expected of a separate population sample of the same species.

Kolopsis yperus Murray, Megirian and Wells, 1993

(Figs 7-15, Tables 4-6)

Type material. Holotype SGM P92117, right P^3 and M^1.

Referred material. P9346, right maxilla fragment with P^3-M^{1-4}, P9236, left maxilla fragment with P^3-M^{1-2}; P961, left maxilla fragment with P^3-M^{1-4}; P962, left maxilla fragment with M^{3-4}; P963, right M^2; P9480, right M^1; P964, right I^1 root; P965, right maxilla with M^{3-4}; P9344, left

Table 1. Comparison of upper cheek teeth measurements of Ongeva LF *Kolopsis torus* compared with range of variability in Alcoota LF *K. torus*. Alcoota LF *K. torus* from Woodburne (1967b: Tables 8 and 9). **L** = length; **W** = width; **WP** = width protoloph; **WH** = width hypoloph.

		P^3		M^1			M^2			M^3			M^4		
		L	W	L	WP	WH	L	WP	WH	L	WP	WH	L	WP	WH
Ongeva															
P9216	L	17.0	14.5	16.6	16.2	17.0	19.7	18.7	19.0	21.5	20.6	19.5	22.0	-	-
	R	-	-	-	16.8	-	19.1	19.2	17.4	-	-	-	-	-	-
P9477		18.3	15.4	18.5	17.3	-	20.5	20.3	19.3	24.0	23.3	19.4	-	21.5	-
Alcoota															
Range		17.1-20.5	13.7-16.1	17.4-20.5	16.2-18.3	16.4-18.7	19.7-22.9	19.2-21.4	17.8-21.4	21.5-25.0	20.4-23.2	17.7-21.1	21.2 -25.3	20.1-23.3	14.8-22.0

Table 2. Comparison of lower cheek teeth measurements of Ongeva LF *Kolopsis torus* compared with range of variability in Alcoota LF *K. torus*. Alcoota LF *K. torus* from Woodburne (1967b: Tables 11 and 12). **L** = length; **W** = width; **WP** = width protolophid; **WH** = width hypolophid.

	P_3		M_1			M_2			M_3			M_4		
	L	W	L	WP	WH	L	WP	WH	L	WP	WH	L	WP	WH
Ongeva														
P92153	-	-	-	-	-	-	-	-	26.1	17.8	17.9	24.4	19.0	17.2
P92178	14.2	9.7	20.3	14.3	14.9	22.4	16.5	17.2	24.0	20.8	18.3	27.5	20.0	17.2
P92152	-	-	18.0	12.2	13.9	20.4	17.9	-	-	-	-	-	-	-
P9474	-	-	-	12.1	12.6	20.0	15.1	14.9	22.0	18.6	17.2	23.1	18.6	17.5
P9475	-	-	17.5	-	-	21.3	-	-	22.7	-	-	25.0	-	-
P9476	-	-	17.1	12.9	13.3	19.6	15.5	15.0	23.4	-	-	-	-	-
P9478	-	-	-	-	-	-	-	-	-	-	-	28.0	18.3	20.2
Alcoota														
Range	12.3-15.5	9.1-11.3	17.2-19.1	12.1-14.8	12.5-15.1	18.7-21.6	14.1-17.3	13.9-16.0	21.8-25.8	16.4-19.7	15.5-18.1	22.1-27.0	17.3-21.0	15.6-20.0

Table 3. Dimensions of the lower jaws of Ongeva LF *Kolopsis torus* compared to the range of variability in Alcoota LF *K. torus*. Alcoota LF *K. torus* data from Woodburne (1967b: Table 13).

	P92153	P92178	P92152	range in Alcoota LF *K. torus*
length of diastema	-	-	43	27.0 - 45.5
mandibular canal to postalveolar process	29	-	29	20.8 - 30.8
post alveolar process to posterior edge of M_4	21	-	-	8.5 - 21.8
depth of horizontal ramus below $M_{3/4}$	53	47	-	42.3 - 54.5
depth of horizontal ramus below $M_{1/2}$	46	45	-	39.2 - 50.9
depth of dorsal edge of jaw to mental foramen	-	13	-	15.2 - 21.8
anterior edge of P_3 to mandibular canal	149	-	-	140.5 - 152.5
anterior edge of P_3 to postalveolar process	129	121	-	118.1 - 136.4
length P_3 to M_4	105	111	-	100.0 - 113.7

dentary with M_{2-4}; P966, left dentary with M_{2-4}; P9223, left dentary with damaged tooth row, M_{2-3} and crushed horizontal ramus; P9344 right posterior part of horizontal ramus of dentary, lacking teeth.

Type locality. Alcoota Station, latitude 22°52'S, longitude 134°27'E. Specimens were recovered from two quarries located on the north and south sides of Hill 1. Both quarries intersect sandy channel deposits situated above an unconformity approximately 10 m above the fossiliferous lacustrine sediments containing the Alcoota Local Fauna.

Fauna. Ongeva Local Fauna.

Rock unit and age. Waite Formation, Cheltenhamian equivalent, late Miocene - early Pliocene.

Revised diagnosis. As given for *Kolopsis yperus* Murray, Megirian and Wells, 1993, with definition amended as follows: P^3 crown ranges from slightly smaller to considerably larger than that of the holotype *Zygomaturus gilli* Stirton, 1967; and, dentary symphysis fused and large genial fossae present.

Description. *Maxilla.* The four new fragments of facial cranium (Figs 7-10) confirm previous observations (Murray *et al.* 1993), based on less complete material, that the cranium of *Kolopsis yperus* lacks many of the specializations that characterize *Zygomaturus trilobus*. The lower margin of the orbit preserved in three specimens (P965, P9236, P961) indicates that the orbits are small, about 30.0 mm in diameter, with thick, rounded lower emarginations. The facial height measured from the inferior orbital margin to the interproximal crevice between the metastyle of M^1 and the parastyle of M^2 ranges from 40.0 mm in P9236 to 60.0 mm in P961.

In the mature specimens, a deep, elliptical suborbital fossa is developed, similar in size and shape to that of *Plaisiodon centralis* Woodburne. This structure is only slightly developed in the youngest individual (P9236). The rounded suborbital crest sweeps posteriorly at about a 45° angle relative to the palatal midline, giving rise posteriorly to the zygomatic process.

The zygomatic process is robust and expanded transversely in P965, being approximately 28.0 mm wide and 16.0 mm thick, with a strongly developed masseteric crest. In P9236, the less mature individual, the zygomatic process is small and compressed laterally. When complete, it would not have extended below the occlusal plane of the molars, whereas that of P965, although broken a considerable distance above its termination, extends more than 20.0 mm below the occlusal plane of the molars. In P965 a low, rounded postorbital eminence is present and the zygomatic root expands into a rounded boss at the confluence of the zygomatic process and base of the zygomatic arch.

Because of numerous cracks, the maxillojugal suture is not easily traced on any of the specimens. It appears to divide the zygomatic process into approximately equal parts in P965, whereas in P9236, the lateral 4/5 of the zygomatic process is formed within the jugal. The suture is clearly defined behind the orbital margin as a narrow crescentic cleft, and as it continues inferiorly it forms a low crest emarginating the lateral side of the suborbital fossa.

The alveolar shelf is narrow but very strongly accentuated by a sharp crest continuous with the internal border of the zygomatic process. The infraorbital canal is preserved on P965. It is located 27.0 mm posterior to the inside of the inferior orbital crest, The optic foramen opens 55.0 mm posterior to the inferior orbital crest. The height of the alveolar shelf ranges from 37.0 mm to 42.0 mm above the M^3/M^4 alveolar margin.

The palatal processes of the maxilla are about 8.0 mm to 12.0 mm thick near the median suture. The palatal surface is flat with shallow longitudinal grooves. The estimated width of the palate at M^3/M^4 is 65.0 mm (P965) and about 60.0 mm at P^3/M^1 (P961). P9346 preserves about 35.0 mm of the diastema. The diastemal crest is rounded and indistinct. A shallow nasolabial fossa is present anterior to the P^3 root.

Upper incisor. The right I^1 (P964) closely resembles the referred specimen NTM P92114 previously described by Murray *et al.* (1993) although it is slightly thinner in section, less curved and slightly less tapered proximally. The tip of the crown is either worn off or broken near the dentine-enamel junction. The specimen is plano-convex in section, being flat-surfaced mesially over its entire length. The maximum thickness of the root is 13.0 mm and approximately 25.0 mm deep anteroposteriorly. Its length along the dorsal margin is about 114.0 mm.

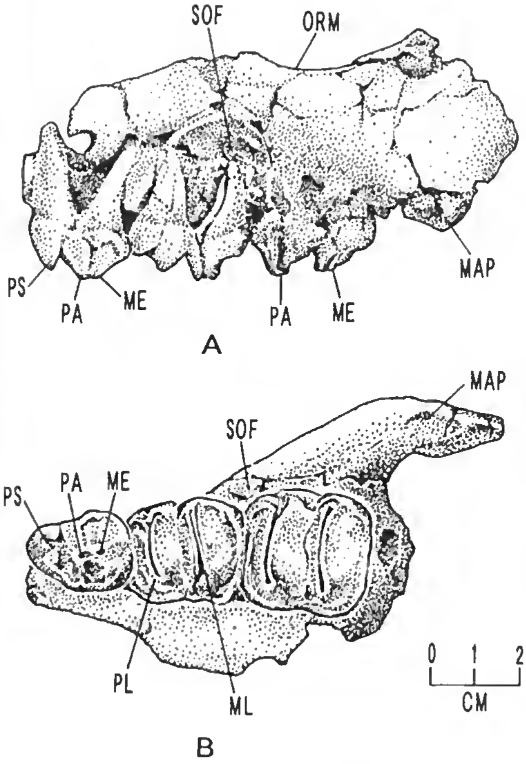

Fig. 7. Left maxilla fragment of a young *Kolopsis yperus* (P9236) in which the teeth show slight wear, the masseteric process is small and the suborbital fossa is scarcely developed; A, labial aspect; B, occlusal aspect. Abbreviations: **PS**, parastyle; **PA**, paracone; **ME**, metacone; **SOF**, suborbital fossa; **ORM**, inferior orbital margin; **MAP**, masseteric process.

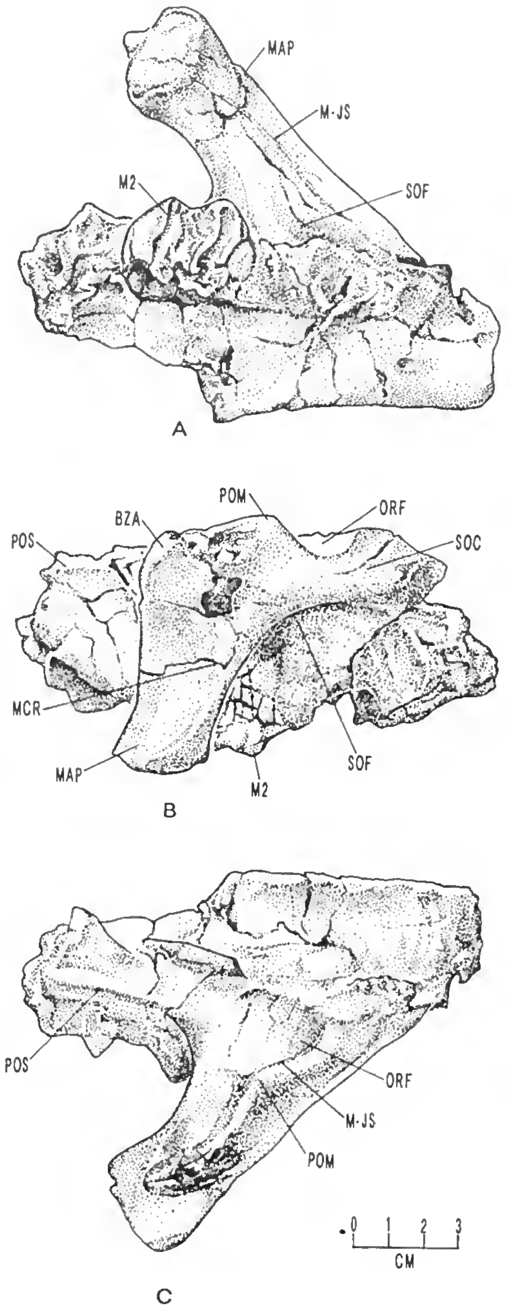

Fig. 8. Right maxilla of *Kolopsis yperus* (P963) preserving the lower margin of the orbit and part of the zygomatic process. The morphology of the orbit and "cheek" region of *Kolopsis yperus* closely resembles that of *Kolopsis torus* in basic shape and orientation; the orbit is open laterally and the suborbital crest trends obliquely posteriorly. Some partial resemblances to *Zygomaturus trilobus* are also present: the zygomatic process is large, wider transversely than anteroposteriorly, and the base of the zygomatic arch indicates a steep posterior orbital margin. A, palatal aspect; B, labial aspect; C, dorsal aspect. Abbreviations: **M2**, second upper molar (M^2); **MAP**, masseteric process; **MCR**, masseteric crest; **M-JS**, maxillo-jugal suture; **POM**, postorbital margin; **ORF**, orbital fossa; **POS**, postorbital shelf; **SOC**, suborbital crest; **SOF**, suborbital fossa.

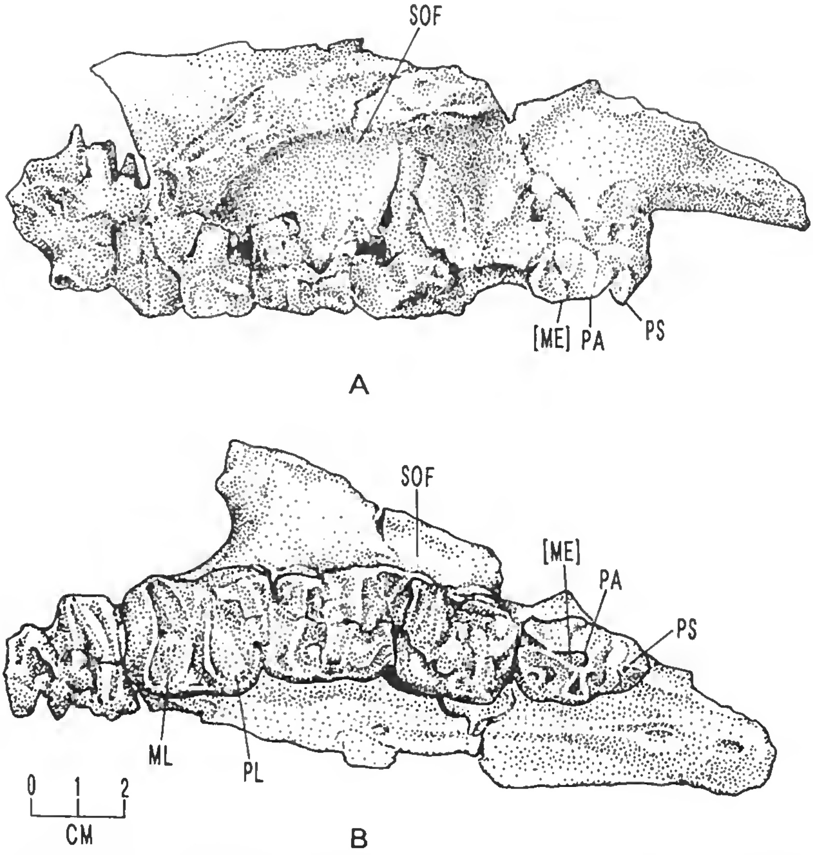

Fig. 9. Right maxilla fragment of *Kolopsis yperus* (NTM P9346). A, labial aspect; B, palatal aspect. Abbreviations: [ME], position of heavily worn metacone; ML, metaloph; PA, paracone; PL, protoloph; PS, parastyle; SOF, suborbital fossa.

Upper premolar. The four P^3 specimens of *K. yperus* are variable in size and outline shape, as characterizes the upper premolars of other taxa in the subfamily Zygomaturinae. The holotype *K. yperus* SGM P92117 is slightly smaller than that of the holotype of *Z. gilli*, whereas that of P9236 is nearly identical at 23.0 mm long and 17.8 mm wide. P961 is larger than the *Z. gilli* holotype (L=24.5 mm, W=20.4 mm) and that of P9346 is longer again (L=26.0 mm) though proportionally narrower (W=19.0 mm).

With the exception of P9346 which is heavily worn, all of the new specimens (Fig. 11) show clear differentiation of the paracone and metacone. They also express a large, transversely broad parastyle closely approximated to the paracone base, a short, strong posterolabial cingulum and variable mesostyle and a crest that ascends the labial side of the parastyle extending from the transverse commissure to the apex of the cusp.

NTM P9236 closely resembles the type specimen of *Z. gilli* in all essential morphological details. As the specimen (P9236) is only slightly worn, the crown height from the apex of the paracone to the enamel-dentine junction is 18.3 mm. It is therefore considerably higher-crowned in proportion to its length than that of *Kolopsis torus*. The transverse link between the paracone and the protocone is high and a small basin is formed on the anterolingual side of the parametacone which is partly enclosed posteriorly by the basal swellings of the hypocone and metacone. The hypocone of P9236 is nearly as large as the protocone. In *Z. gilli* the hypocone, which is a variably developed cusp in all zygomaturine species in which it is present, is small.

The parastyle is wider than long. A thick lingual crest ascends its apex. The labial crest is weaker. A thick, rounded preparacrista extends to the base of the parastyle from the apex of the paracone. The triangular paracone is much larger

Table 4. Upper cheek teeth measurements of *Kolopsis yperus*. L = length; W = width; WP = width protoloph; WH = width hypoloph.

	P^3		M^1			M^2			M^3			M^4		
	L	W	L	WP	WH	L	WP	WH	L	WP	WH	L	WP	WH
SGM P92117 (R)	21.5	17.1	24.3	21.2	21.2	-	-	-	-	-	-	-	-	-
P9236 (L)	23.0	17.8	24.4	21.5	22.7	27.0	25.0	24.6	-	-	-	-	-	-
P962 (L)	-	-	-	-	-	-	-	-	33.0	27.7	22.2	30.5	24.8	19.5
P961 (L)	24.5	20.4	23.0	22.7	23.3	27.0	26.1	24.7	30.6	28.4	25.2	31.2	26.2	21.0
P963 (R)	-	-	-	-	-	30.5	27.0	26.5	-	-	-	-	-	-
P9480 (R)	-	-	26.0	23.0	24.3	-	-	-	-	-	-	-	-	-
P9346 (R)	26.0	19.0	26.4	21.4	21.6	27.0	26.1	24.4	30.5	27.3	23.0	30.4	24.6	-

Table 5. Lower cheek teeth measurements of *Kolopsis yperus*. L = length; W = width; WP = width protolophid; WH = width hypolophid.

	P_3		M_1			M_2			M_3			M_4		
	L	W	L	WP	WP	L	WP	WH	L	WP	WH	L	WP	WH
P9483 (R)	-	-	-	-	-	-	21.0	-	29.0	23.9	21.5	30.9	25.0	20.0
P966 (L)	-	-	-	-	-	31.5	-	-	32.8	-	21.5	32.5	22.5	20.5
P9433 (L)	-	-	-	-	-	26.5	21.0	22.0	30.7	25.0	21.5	30.2	23.9	21.0

Table 6. Dimensions of *Kolopsis yperus* dentaries. * indicates approximation.

	P9433 (L)	**P9433 (R)**	**P9483**	**P966**	**P9233**
depth of horizontal ramus below $M_{3/4}$	63.0	60.0*	66.6	55.0	60.0*
depth of horizontal ramus below $M_{1/2}$	50.5	-	53.0	-	76.0*
alveolar length, P_3 to M_4	135.2	-	142.0	128.5	132.0
thickness of symphysis	32.5	-	28.2	34.0	40.0
length mental foramen (?MEF) to masseteric fossa (?MAF)	168.0	-	152.5	-	174.5
thickness of coronoid (?COR) at postalveolar shelf (?PAS)	41.4	33.0*	37.0	41.0*	48.0

than the small oval metacone. A shallow labial crease extending from the mesostyle to the apex of the parametacrista corresponds to the division of the paracone and metacone. The mesostyle is a small, irregularly-shaped enamel crest composed of two small cuspules situated immediately anterior to a short, oblique posterolabial cingulum.

The P^3 of P961 is similar in overall shape to P9236 though larger, with much thicker enamel and deeper sulci between the cusps. The crown is heavily worn, exposing dentine on all cusps. The edges of the worn enamel crests are slightly rounded and less crisply defined than on the adjacent molar lophs. The parastyle, which is proportionally narrower transversely than that of P9236, is situated close to the base of the paracone. The lingual crest of the parastyle is more distinct than the labial crest and the tranverse sulcus is deeper lingually than labially.

The protocone is large and bulbous, being separated from the base of the parametacone by deep anteroposteriorly trending clefts extending from the middle of the transverse link. A shallow fossa, less distinct than in P9236, is present on the lingual side of the parametacone. The paracone is larger than the metacone which is separated by about 6.5 mm from the latter by a broad, shallow labial sulcus.The mesostyle is composed of a low enamel shelf from which a small cuspule arises, separating a shallow labial basin into two parts.

The P^3 of P9346 is more elongated than that of P961, but is neither as wide nor as thickly enamelled. Because P9346 was recovered before P961, the substantial differences in the size and morphology of the crown from that of the type specimen of *K. yperus* raised the possibility that it might represent another species. In particular, the narrow, elongated crown bears a striking resemblance to the P^3 of *Plaisiodon*

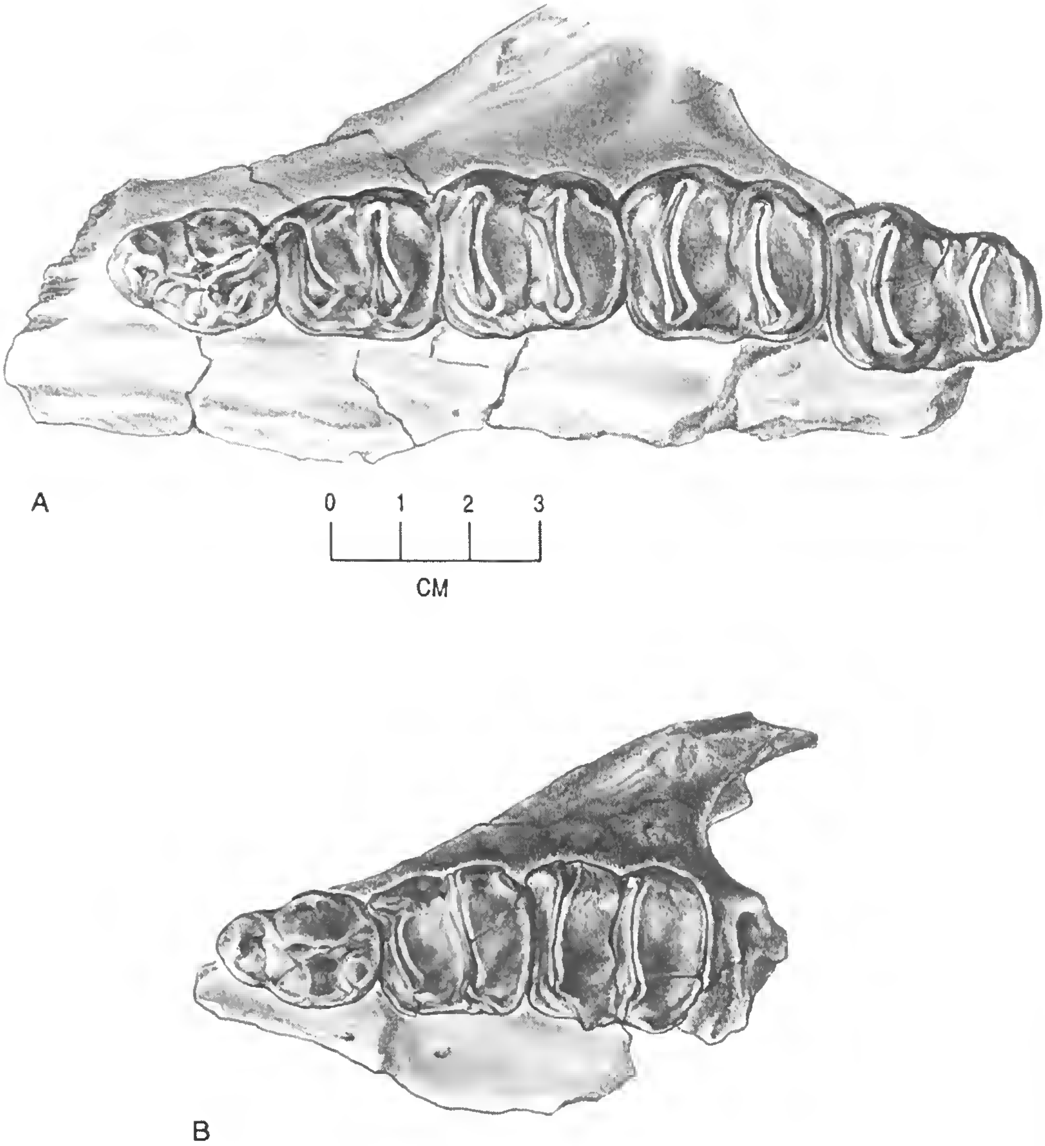

Fig. 10. Occlusal views of left cheek tooth rows of *Kolopsis yperus*. A, P961; B, P9236.

centralis. However, since *Plaisiodon centralis* consistently lacks any trace of a mesostyle or a labial crest on the parastyle, both of which are well-developed on P9346, the tooth cannot be allocated to that species either. The subsequent recovery of additional specimens closed the morphological gap sufficiently to confidently place the specimen within *K. yperus* as a rather extreme morphological variant. While the observed range of variation in the P^3 morphology of *K. yperus* is in accord with the extent of variability encountered in other zygomaturine species for which a population sample is available, had we not found any intermediate specimens, its status would probably have remained dubious.

As in other specimens of *K. yperus*, the parastyle of P9346 is large and pressed close to the base of the paracone. The transverse sulcus is deep on both sides of the parastyle, meeting the labial and lingual ascending crests. The anterior profile of the parastyle is concavoconvex with a prominent basal expansion giving way to the slightly recurved tip. A large tear-drop shaped dentine exposure dominates the paracone. A faint secondary expansion of the enamel crests at the posterior end of the exposure probably

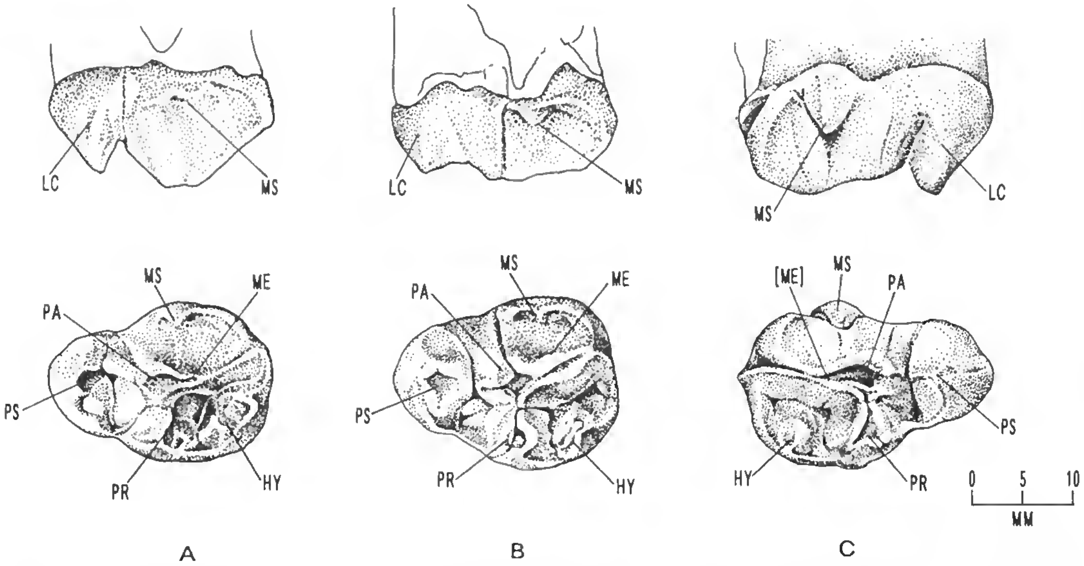

Fig. 11. P³ specimens of *Kolopsis yperus*. **A**, P9236 left, labial and occlusal views; **B**, P961, left, labial and occlusal views; **C**, P9346, right, labial and occlusal views. Abbreviations: **HY**, hypocone; **LC**, labial crest of parastyle; **MS**, mesostyle; **PA**, paracone; **PR**, protocone; **PS**, parastyle.

represents the metacone, which is separated from the paracone by a faint labial groove. The mesostyle is a large triangular point of enamel isolated from the posterolabial cingulum by a V-shaped groove.

Upper molars. The molar row is curved (e.g. Fig. 10). The molars decrease in size in the order M³, M⁴, M², M¹. The M¹ crown is nearly rectangular, though slightly longer labially than lingually. The labial sides of the two moieties bulge prominently over the roots. The lingual side of the lophs are considerably higher than the labial side. The median valley is wide and open lingually but partially occluded labially by the postparacrista. There is no labial cingulum or mesostyle present.

The protoloph is strongly bowed anteriorly with a transversely narrow crest emarginating its deeply excavated posterior face. The metaloph is less curved and transversely much wider. The lingual side of the protocone slants into the loph, accentuating a wide expanse of the cingulum on the anterolingual corner of the crown. The posterior base of the protocone presents a flattened triangular facet, from which a low, oblique crest arises, extending from the apex of the protocone to the interloph sulcus. The labial side of the posterior fossa of the protoloph is formed by a low but distinct postparacrista. The parastyle is a large crescentic cuspule originating from immediately below and slightly lingual to the paracone, extending anteriorly to meet the base of the postmetacrista of the P³ and forming a composite shearing crest.

The precingulum is thick and wide, expanding anterolingually around the base of the protocone where it merges with the lingual cingulum. The lingual cingulum expands slightly around the mouth of the interloph valley, emarginating a shallow interloph basin, then ascends the base of the hypocone a short distance, where it terminates. The postcingulum originates in a vertical crest extending about half-way up the posterolingual side of the hypocone. Expanding lingually near the base of the hypocone, the postcingulum continues around the base of the posterior facet of the metaloph to merge with a large crescentic metastyle on the labial corner of the P³ crown.

The M² is much larger than M¹ and more uniformly rectangular in occlusal outline. The protoloph and metaloph are of about equal transverse width. The protoloph is less curved than in M¹ and the posterior face is not as confined or as deeply concave. The parastyle is smaller and situated lower on the precingulum. The precingulum extends lingually to the anterolingual side of the protocone base where it terminates, after ascending the side of the protocone a short distance. The lingual cingulum commences as a shelf-like emargination of the mouth of the interloph valley, terminating on the anterolingual side of the hypocone. The postcingulum originates from the posterolingual side of the hypocone, continuing around the base of the posterior facet of the metaloph to meet the low elliptical, swelling of the metastyle. The postparacrista is reduced to a low enamel bulge above the interloph sulcus at the base of the paracone. A short, weak labial cingulum is present in the mouth of the interloph valley.

M^3 is longer and asymmetrical, in that the metaloph is more obliquely oriented than the protoloph. Although the crests of the protoloph and metaloph are about equal in transverse width, the basal width of the anterior moiety greatly exceeds that of the posterior face. The parastyle is reduced to a small expansion of the precingulum. The interloph valley is much wider than in M^2 and the lingual cingulum is weaker, though similar in extent to that of M^2. The M^3 metastyle is about half the size of the M^2 metastyle and is located low on the posterolabial corner of the postcingulum. The lingual side of the postcingulum terminates on the posterior side of the base of the hypocone, and does not ascend the cusp as in M^2 and M^1.

M^4 is similar to M^3 except for its smaller size and much narrower metaloph. A small parastyle is present on the anterolabial corner of the precingulum. The metastyle is absent. A faint labial cingulum extends across the median valley mouth. The lingual cingulum is like that of the preceeding molar.

Mandible. Three similarly preserved hemimandibles are missing the lower incisor, P_3, $M_{1\text{-}2}$ and the posterior part of the horizontal ramus including the posterior masseteric eminence and the angular process. A fourth specimen represents a fragment of the posterior part of the ramus from which the molars are missing. These are more heavily constructed and in particular, much thicker in section and less sinuous in their profile than the equivalent element of *Kolopsis torus*.

The dentaries (e.g. Figs 12 - 14) are fully ankylosed at the symphysis and are broken on either the medial or lateral side of the median symphyseal crest. The horizontal rami taper gradually towards the symphysis, the profile of the inferior border ranging from slightly to moderately convex. The digastric process is fairly distinct, though low and rounded, being accentuated posteriorly by a broad, shallow postdigastric sulcus. The inferior border of the horizontal ramus is thick, though bordered ventrally by a sharp crest extending forward from the digastric process to the outer margins of large, deep genial fossae. The genial fossae are paired crescentic pits, separated by a low median crest. These extend across the entire ventral surface of the posterior margin of the symphysis.

The symphysis is massively thick and elongated. The ventral surface is horizontal while the dorsal surface slants upwards to form a U-shaped sublingual sulcus. The root fragment preserved in P9223 indicates that the lower incisors were procumbent to about the same degree as in *K. torus*. The round mental foramen is large on all specimens, opening anteriorly about 20.0 mm below the alveolar margin of the P_3 root within a shallow, oval subalveolar fossa.

The lateral surface of the horizontal ramus becomes strongly convex immediately behind the fossa, then flattens and narrows slightly at the transition to the ascending ramus. The masseteric fossa is moderately deep. A small masseteric foramen is present in three of the specimens and may be obscured by damage to the area in the fourth individual. The submasseteric crest is strong but the postmasseteric eminences and angular processes are missing on all specimens.

The intercoronoid sulcus is conspicuous for its considerable width, and the base of the coronoid crest is particularly massive. A shallow 10.0 mm diameter basin is contained within the postalveolar shelf. The postalveolar process, represented by a low tubercle or thickening of the margin of the postalveolar shelf, is weakly developed on all specimens.

The digastric fossa tapers anteriorly to the level of interproximal M_2/M_3. It is deepest and widest at the level of the posterior root of M_4. The pterygoid fossa is confluent with the digastric fossa, though a faint crest indicates a definite separation of the two structures. The alveolar protuberance of the last two molars is massive and overhangs the digastric fossa by as much as a centimetre in P9344.

The markedly tangential orientation of the cheek tooth rows of this species results in a considerable overhang of the alveolar margins by the protolophid of M_2 and the hypolophid of M_4. A considerable range in size and basic shape of the dentaries is evinced by the Ongeva sample, suggestive of sexual dimorphism. P9483 and P9344 are smaller, more slender and have straighter ventral profiles of the horizontal rami than P966 and P9223.

Lower molars. The lower premolar and first molar are not known for this species. Molars 2-

4 are essentially alike, their length and width gradually increasing posteriorly. The lower molars are relatively broad and rectangular, with thick enamel and wide, robust lophids. The interlophid valleys are wide and U-shaped in labial aspect. On all molars the hypolophids are more curved and transversely narrower than the protolophids. The precingulids are weak and confined to the labial and lingual corners of the base of the protolophid. The postcingulid projects posteriorly in the form of a narrow, rounded shelf with a slight elevation below the middle of the hypolophid. A low metalophid is present on the last two molars, being more strongly expressed on M$_4$.

Systematic considerations. An indication of P^3 size range in *K. yperus* is provided by the new material. The type *K. yperus* P^3 is smaller than that of the *Zygomaturus gilli* type by 2.0 mm of length and 0.3 mm of width. The largest of the new specimens exceeds the P^3 length of *Z. gilli* by 4.5 mm. The degree of variability in *K. yperus* (comparable to that observed in other zygomaturine species) encompasses that of the sole specimen of *Z. gilli*, which, when combined with a morphological similarity, substantially increases the likelihood noted by Murray *et al.* (1993) that the two taxa are synonymous. However, more specimens are needed of *Z. gilli*, including the M^1, before a synonymy can be objectively established.

While *Zygomaturus gilli* has taxonomic priority over *Kolopsis yperus*, generic distinctions within the Zygomaturinae may require redefinition if they are to meaningfully reflect hypotheses of evolution in the group and express their biochronological utility. The morphological similarity of *K. yperus* and *Z. gilli* indicates that they are at a similar stage of evolution.

The basic structural progression from *Neohelos* to *Kolopsis* to *Zygomaturus* was originally outlined by Stirton *et al.* (1967). The geno-

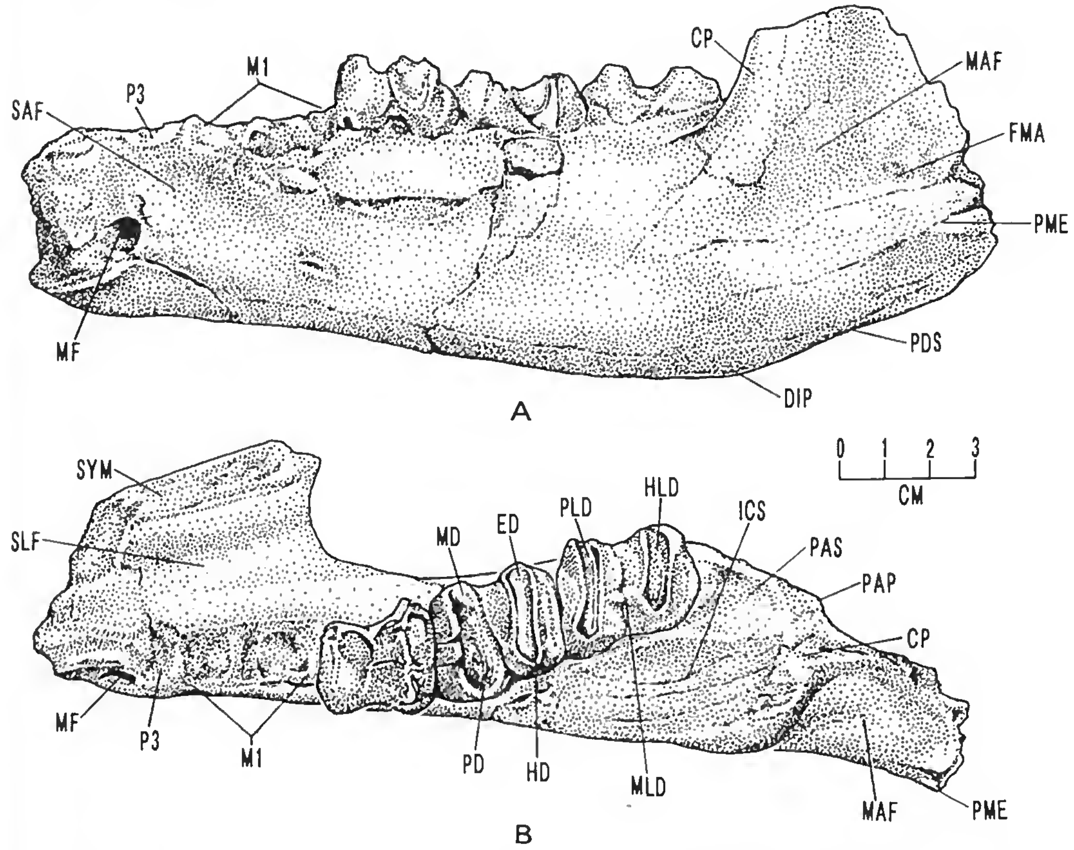

Fig. 12. Left dentary of *Kolopsis yperus* (P9344). A, lateral aspect; B, occlusal aspect. Abbreviations: **M1**, first lower molar; **CP**, anterior crest of coronoid process; **DIP**, digastric process; **ED**, entoconid; **FMA**, masseteric foramen; **HD**, hypoconid; **HLD**, hypolophid; **ICS** intercoronoid sulcus; **MAF**, masseteric fossa; **MD**, metaconid; **MF**, mental foramen; **MLD**, metalophid; **P3**, lower permanent premolar; **PAP**, post-alveolar process; **PAS**, post-alveolar shelf; **PD**, protoconid; **PDS**, post-digastric sulcus; **PLD**, protolophid; **PME**, posterior massteric eminence; **SAF**, subalveolar fossa; **SLF**, sublingual fossa; **SYM**, symphysis.

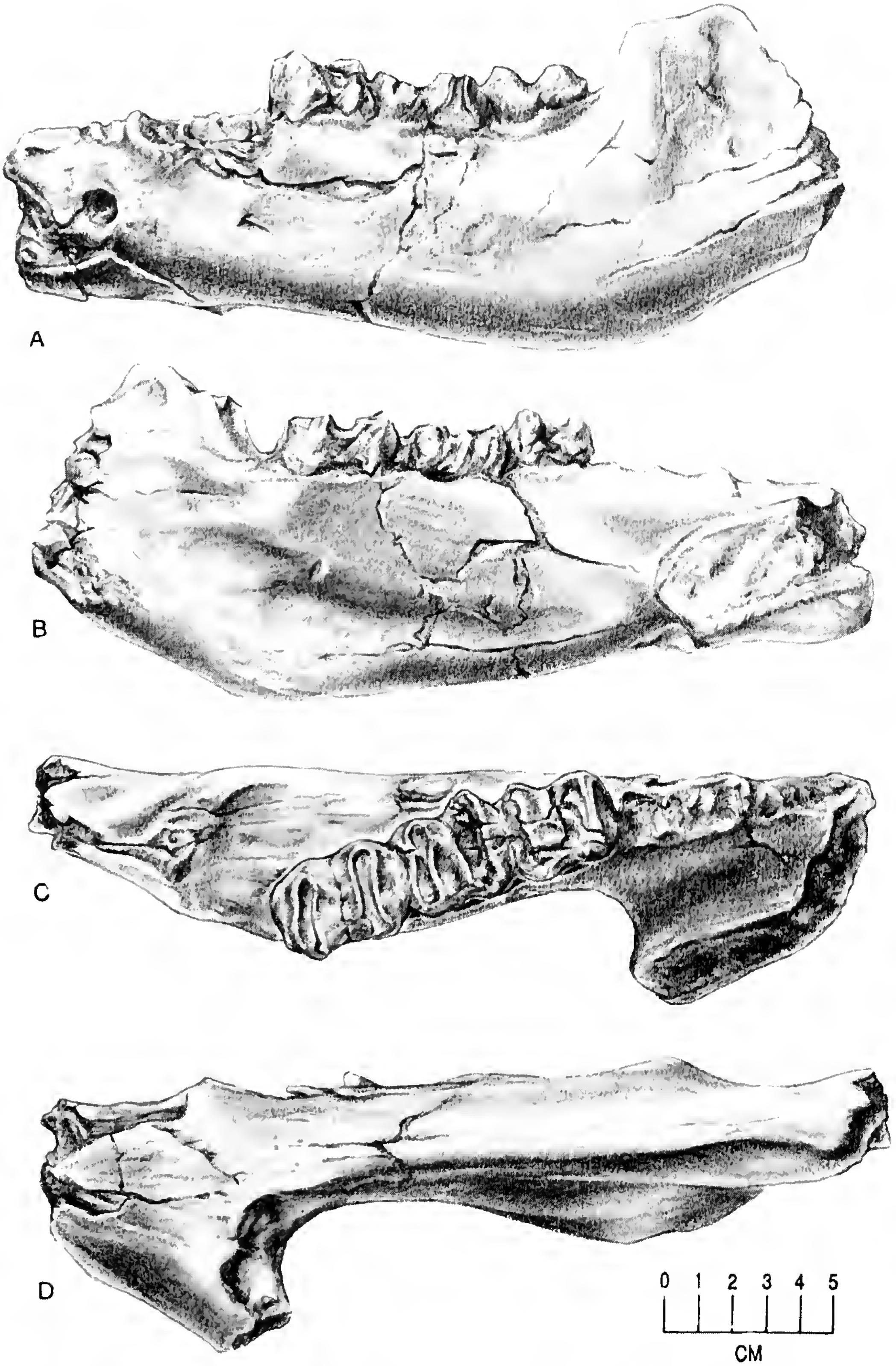

Fig. 13. Left dentary of *Kolopsis yperus*, NTM P9344, note slender horizontal ramus and straight inferior border. **A**, lateral aspect; **B**, internal aspect; **C**, occlusal aspect; **D**, ventral aspect.

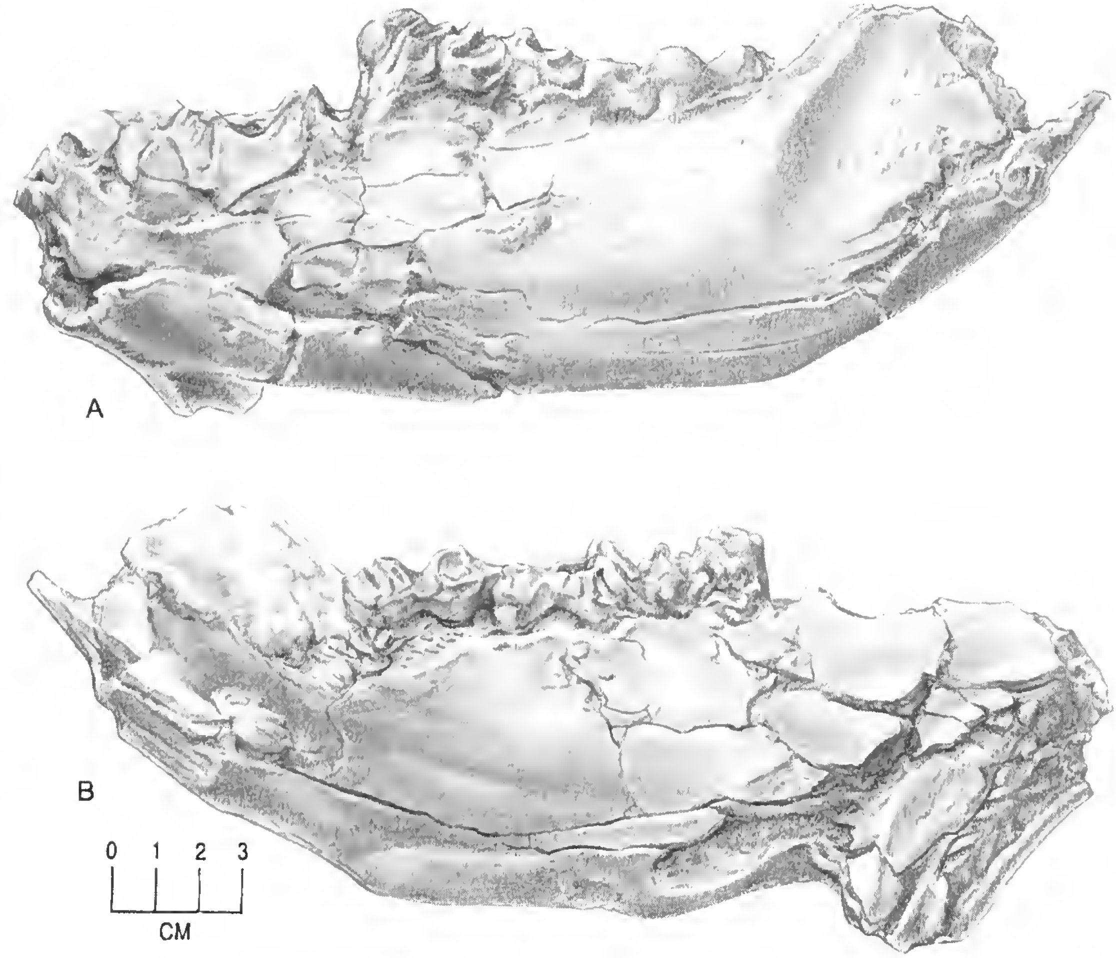

Fig. 14. Left dentary of *Kolopsis yperus*, P966; an example of the larger, deeper specimens with a rocker-shaped inferior profile. A, lateral aspect; B, internal aspect.

typic (and in 1967, the only known) species of *Neohelos* and *Kolopsis* expressed degrees of morphological difference from each other, and from previously described species of *Zygomaturus*, that warranted generic distinction. Subsequently described species have closed the gaps between genotypes, so that generic classification now subdivides what appears to be a successional spectrum.

Stirton (1967) had no difficulty in placing *keanei* with other species of *Zygomaturus*, but placed *gilli* in the same genus with reservations. Murray (1992) also expressed reservations about its placement.

Primitively (as expressed in early and mid Miocene species of *Neohelos*), the P^3 parametacone is expressed as a single cusp. Incipient division of the cusp first appears in the mid Miocene in an undescribed new species of the genus *Neohelos* (Murray *et al.* in prep.). A clear and consistent division of the cusp is a shared derived character state of late Miocene and younger zygomaturines placed in *Kolopsis*, *Zygomaturus*, *Maokapia* Flannery, and *Hulitherium* Flannery and Plane. Taxonomic distinctions and subdivision of this clade using dental characters, however, relies on the upper molars as well, especially the M^1.

In an attempt to use the established nomenclature in a manner that reflects both morphology, hypotheses of relationship, and stratigraphic succession, we follow Murray (1992) in recognising the genus *Kolopsis* as: species possessing elongated P^3 with consistently and distinctively divided parametacone, P^3 crown approximately equal in length to M^1 crown; M^1 with large parastyle forming functional shearing crest with the postmetacrista of P^3; and the genus *Zygomaturus* as species possessing short, broad P^3 with divided parametacone, crown significantly reduced in size relative to M^1; M^1 parastyle reduced, resulting in diminished shearing function and squaring of occlusal outline.

According to these definitions, *gilli* groups with *Kolopsis* on the basis of P^3 morphology, but what is not known of *gilli* is the state of the M^1 parastyle, and the size of P^3 relative to M^1. Other *Zygomaturus* spp., *Maokapia* and *Hulitherium* are derived with respect to *Kolopsis* in shortening and broadening of the P^3, and the P^3 reduced in size relative to M^1. These character states (amongst a much larger suite of derived dental and cranial characters) were used by Murray (1992) to define a clade, the Zygomaturini, which is a crown group based in the mid Pliocene on *Z. keanei*.

There remains within this model and scope of this work the question of which of *Kolopsis torus* or *Kolopsis yperus* most likely gave rise to *Z. keanei* and its descendents. As these *Kolopsis* species coexist in the Ongeva Local Fauna, they must share an ancestor. The new *Neohelos* species mentioned above has no character states that preclude it from ancestry of either species. The molars of *K. torus* are practically indistinguishable in size and morphology from this. However, the P^3 crown is substantially reduced in height and also relatively much lower in comparison with all species in the *Z. keanei* crown group. A reduced P^3 crown thus may represent an autapomorphy of *Kolopsis torus*. On the other hand, *Kolopsis yperus* retains a high-crowned P^3 similar in proportion, though larger than that of the advanced *Neohelos* species, and therefore is more plausible as an ancestor of *Zygomaturus keanei* (Fig. 15).

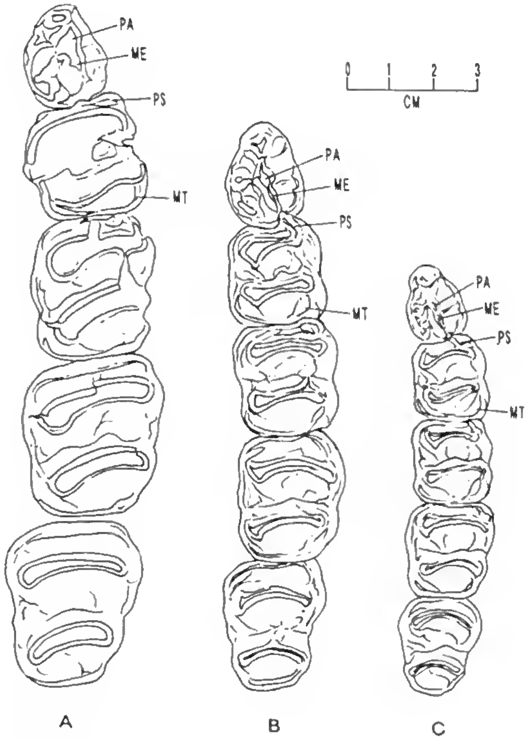

Fig. 15. Scale comparison of the cheek tooth rows of: A, *Zygomaturus keanei* Stirton; B, *Kolopsis yperus*; and C, *Kolopsis torus*. *Z. keanei* after Stirton (1967: fig. 2).

Any formal taxonomic revisions, however, should wait until descriptions of new zygomaturine species are published (B. MacNess pers comm.; Murray *et al.* in prep.), and hypotheses of relationships tested further.

Eusuchia Huxley
Crocodylia Gmelin
Crocodylidae Cuvier
Quinkana Molnar
species indet.

(Figs 16-18, Table 7)

Material. NTM P9229, right dentary fragment preserving five partial alveoli; P9226, P9227, P9230, and P91163-(12 to 21), osteoderms; P91163-(1 to 4), and P9232-(1 to 11), laterally compressed tooth crowns.

Description. The structure of the right dentary fragment, NTM P9229, is shown in Figure 16. The fragment represents the posterior portion of dentary in the vicinity of the foramen for the Ramus intermandibularis medius (a branch of the trigeminal nerve), visible in medial view, and opening through the lateral wall of the primordial canal of the mandible.

The most striking feature of the fragment is a massive, laterally-projecting longitudinal crest along the dorsolateral margin of the dentary ramus. Sculpture is most strongly developed on the lateral face, but continues over the crest and around onto the ventral surface, where its expression is more subdued. Laterally, the sculpture is dominated by marked ridges and sulci, with several large nutrient foramina opening posteriorly. Ridges and sulci are also present on the ventrolateral crest, but augmented by numerous, small, rounded pits. Ventrally, the ridges and sulci are greatly subdued, the pits are smaller but more numerous, and the result is an almost granular surface texture.

Five partial, closely-approximated alveoli are represented. In dorsal view, the alveoli are longer (antero-posterior dimension) than they would have been wide when complete (transverse dimension). In slightly dorsolateral view it is apparent that the long axes of the more complete alveoli are inclined, rather than parallel, to the lateral margin of the dentary. The anterior alveoli are slightly larger than the two most posterior ones, but the size difference is not large, suggesting an animal with a rather isodont dentition.

The isolated tooth crowns are laterally compressed and recurved (Fig. 17, Table 8), with prominent anterior and posterior carinae. Many of the crowns flare medially near the base, resulting in basal width (transverse dimension) to length (anteroposterior dimension) ratios that are greater than at more distal parts of the crown. The Ongeva teeth show relatively little variation in size and proportions, and while it impos-

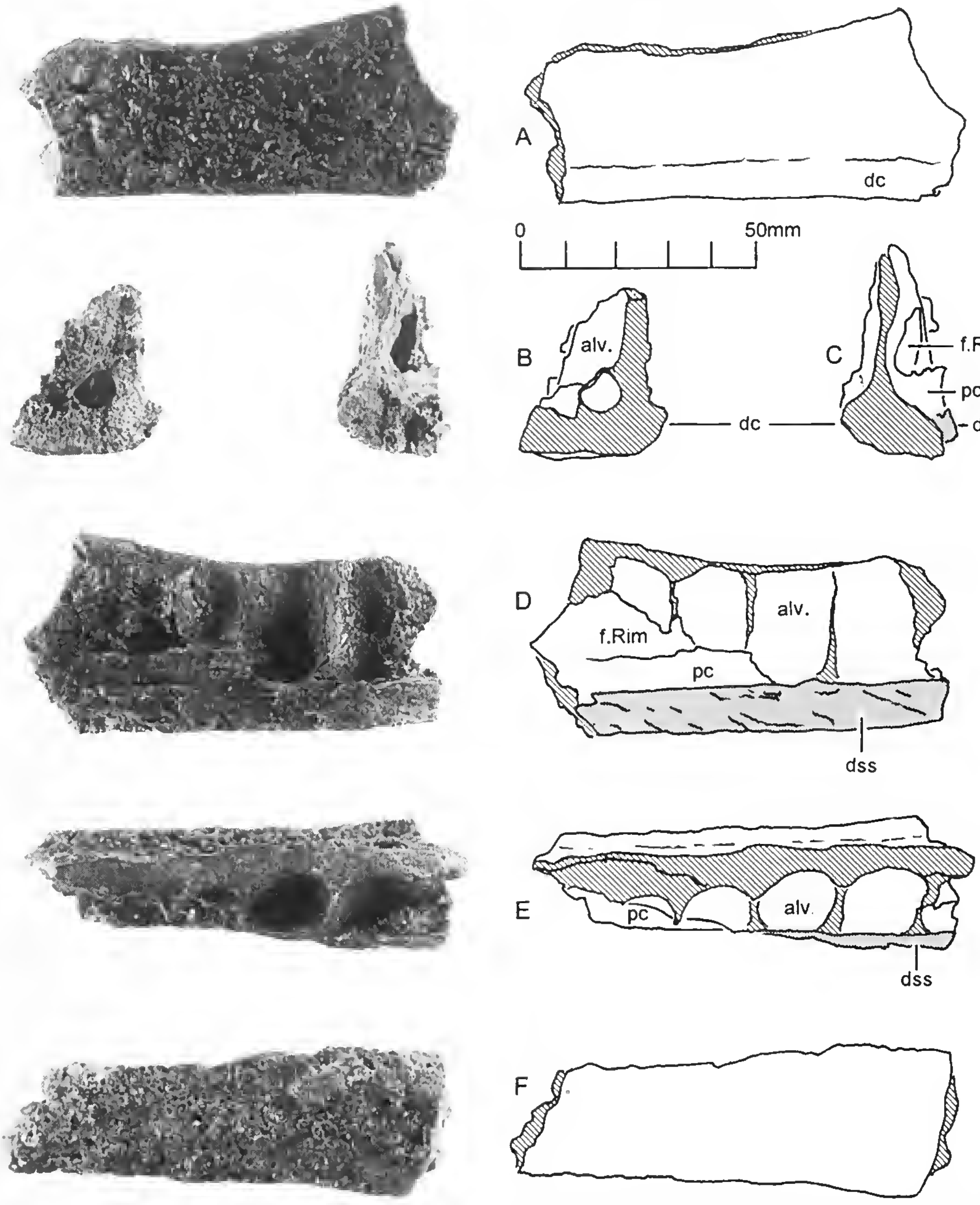

Fig. 16. Ongeva Local Fauna *Quinkana* sp. dentary fragment P92229 in **A**, right lateral; **B**, anterior; **C**, posterior; **D**, medial; **E**, dorsal and **F** ventral. Abbreviations: **alv.**, alveolus; **dc**, dentary crest; **dss**, dentary-splenial suture; **f.Rim**, foramen for the Ramus intermandibularis medius; **pc**, primordial canal of the mandible.

sible to ascertain the number of individuals that might be represented, or where in the dentition the individual teeth came from, the sample also suggests that a species with a rather isodont dentition is present. For most teeth, preservation is such that microscopic features of the carinae are no longer discernible. However, on P91163-4, P9232-3 and P9232-5, segments of the carinae retain fine, evenly spaced serrations (ca. 6 or 7 per mm).

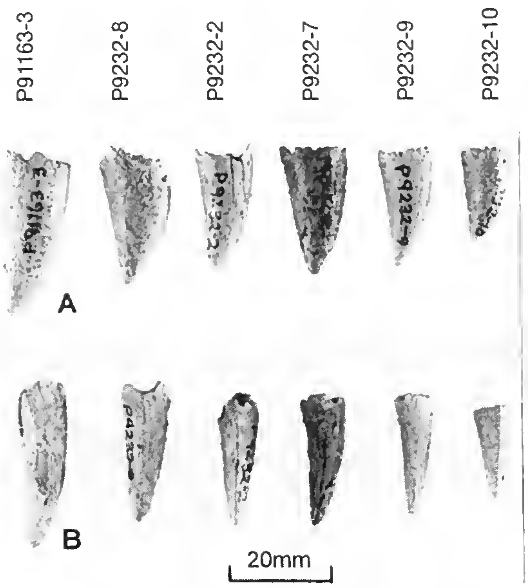

Fig. 17. A selection of *Quinkana* sp. teeth in A, lateral and B, anterior or posterior views.

The osteoderms are variously of rectangular to irregular outline (Fig. 18). Medial crests are very weakly to strongly developed. The sculpture consists predominently of anastomosing ridgelets bounding irregular pits, or sulci radiating from the medial crests. Some have a dorsal, anterior flattened area where they imbricated with the adjacent anterior osteoderm, and/or a corresponding ventral posterior articulating surface. Typically, one or both lateral edges preserve sutures. The variety of shapes, degree of crest development, and distribution of sutural and imbricating surfaces suggests that dorsal armour from various regions of the trunk are represented.

Comparative remarks. The dentary fragment retains several characters diagnostic of the two known species of *Quinkana*, *Q. fortirostrum* Molnar, 1981, and *Q. timara* Megirian, 1994. These include alveolar morphology indicative of a closely approximated, relatively isodont dentition, laterally compressed teeth, and long (anteroposterior) axes of the teeth inclined to the lateral margin of the dentary ramus. A ventrolateral crest on the dentary ramus is known to occur in *Quinkana timara*, but no comparable *Q. fortirostrum* material is known.

The associated Ongeva Local Fauna teeth are consistent in their morphology with the dentary

Table 7. Morphometrics of Ongeva Local Fauna *Quinkana* sp. teeth, compared with *Q. timara* (Megirian 1993: Table 2), and Croyden *Quinkana* sp. (after Molnar 1981: Table 2). Dimensions in mm; bracketed figures are estimates.

Specimen	Length 'L'	Width 'W'	Height 'H'	W/L	Serrations per 5mm (approx.)
P91163-1	[14.2]	[10.4]	[32.5]	[0.73]	-
P91163-2	[13.7]	-	[25.5]	-	-
P91163-3	13.7	[10.0]	34.3	0.73	-
P91163-4	-	-	>23.5	-	30
P9232-1	10.3	7.0	23.3	0.68	-
P9232-2	11.7	[8.3]	26.6	[0.71]	-
P9232-3	-	11.9	30.6	-	30
P9232-4	10.5	7.2	21.4	0.69	-
P9232-5	-	-	31.8	-	35
P9232-6	12.2	9.6	24.5	0.79	-
P9232-7	13.7	9.2	26.3	0.67	-
P9232-8	[14.7]	[10.3]	28.5	0.70	-
P9232-9	10.8	7.6	24.1	0.70	-
P9232-10	10.2	7.3	18.7	0.72	-
P9232-11	-	-	>26.4	-	-
Range					
Ongeva LF *Quinkana* sp.	10.2 -14.7	7.0 -11.9	18.7 -34.3	0.68-0.79	30 -35
Q. timara (n = 14)	5.3 - 9.2	2.2 - 5.0	3.5 -14.4	0.37-0.79	35 -50
Croydon *Quinkana* sp. (n = 4)	8.0 -11.0	4.4 -10.3	-	0.54-0.64	18 -27

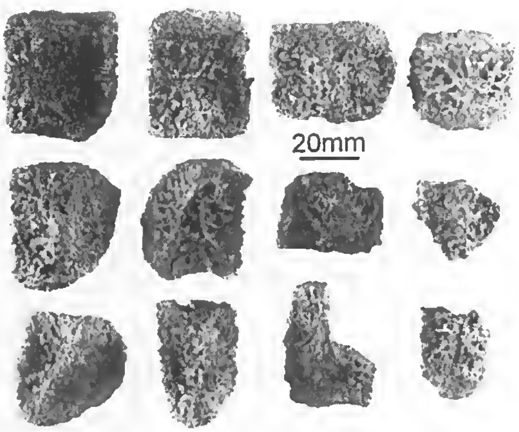

Fig. 18. A selection of osteoderms, in dorsal view, assigned to *Quinkana* sp.

alveoli, but are not as compressed as the most extreme examples of *Q. timara*. They correspond to the higher width to length ratios recorded for *Q. timara*, and are slightly less compressed than Pliocene *Quinkana* sp. specimens from Croydon, Queensland (Table 7). Many of the Ongeva Local Fauna teeth flare medially near the base, resulting in basal width to length ratios that are somewhat higher than along the rest of the crown. The frequency of serrations of Ongeva Local Fauna teeth are equal to, or lower, than in *Q. timara*, but higher than in Croydon *Quinkana* sp. The sole specimen of *Quinkana fortirostrum* is edentulous. A species determination is not possible on the basis of the available material.

Osteoderms are of little diagnostic value in distinguishing Australian fossil taxa at this stage, as no detailed comparative studies have been made. Megirian *et al.* (1991: fig. 8) illustrated two osteoderms included in *Harpacochampsa camfieldensis* which differ from the Ongeva osteoderms in having circular pits rather than ridges and sulci. The Ongeva Local Fauna osteoderms are provisionally assigned to *Quinkana* sp. on the basis of association and the present lack of any evidence of another crocodilian taxon at the Ongeva locality.

PALAEOENVIRONMENTAL RECONSTRUCTION AND FAUNAL SUCCESSION

Murray and Megirian (1992) contrasted the central Australian Alcoota LF (late Miocene) with the mid Miocene Bullock Creek Local Fauna from the north central Northern Territory. For practical reasons, only a selection of material from each assemblage was chosen for analysis, and while various calculations were presented on such things as relative abundances, the approach used was descriptive, with any calculations merely illustrating qualitative differences. The approach was intended to facilitate a first order approximation of '...the pattern of succession, the factors of mortality, the similarities and differences in community structure, [and] the shared and contrasting palaeoenvironmental factors ...' (Murray and Megirian 1992: 195). A similar approach is used here to compare the two Waite Formation assemblages, and as with the earlier work (Murray and Megirian 1992), it is hoped that more rigourous methods can be applied in the future.

The Ongeva LF beds contain fossils in significantly lower concentrations than was found in the Alcoota LF beds. Recovery of the Ongeva LF is further limited by the large overburdens that accompany excavating into the steep sides of Hill 1. On the other hand, the Alcoota LF beds are very rich and relatively extensive beneath a surface of low relief. Large quarries have been developed by the removal of overburden by heavy machinery. In terms of future prospects, the Ongeva quarries will probably never produce the quality and range of material, and taxonomic diversity already recovered from the Alcoota quarries. Quarrying on Hill 1 will continue with the primary objective of recovering diagnostic material of forms already known to be present in the Ongeva LF, and hopefully, additional taxa. Although the following comparisons are based on unequal samples, the differences in the incidences of certain species and the total absence of others suggests that the two faunas sample somewhat different communities.

The Ongeva LF is considerably less diverse than the Alcoota LF (Table 8). Both faunas are dominated by large herbivores, notably diprotodontids and dromornithids. Based on preliminary identification of the Ongeva dromornithids, both faunas contain (cf.) *Genyornis* and (cf.) *Ilbandornis*. At the specific level they share only *Kolopsis torus*: the Alcoota LF contains several diprotodontid herbivores not represented in the Ongeva LF (*Alkwertatherium*, *Palorchestes*, *Pyramios*, and *Plaisiodon*), while *K. yperus* is unique to the Ongeva LF.

In the Alcoota Local Fauna, *K. torus* and *Plaisiodon centralis* are closely associated by

Table 8. Comparison of the Alcoota and Ongeva Local Faunas. Alcoota LF after Murray and Megirian (1992: Table 2).

		Alcoota LF	Ongeva LF
MOLLUSCA	Gastropoda	undetermined	-
REPTILIA	Chelidae	undetermined	-
	Crocodylidae	*Baru* cf. *darrowi*	-
		-	*Quinkana* sp.
	Varanidae	?*Megalania*	-
AVES	Casuariidae	*Dromaius* sp.	-
	Dromornithidae	*Dromornis stirtoni*	cf. *Dromornis*
		Ilbandornis lawsoni	cf. *Ilbandornis*
		Ilbandornis woodburnei	
	Anatidae	undetermined	-
	Accipitridae	undetermined	-
	Phoenicopteridae	undetermined	-
MAMMALIA	?Peramelomorphia	undetermined	-
	?Dasyuridae	undetermined	-
	Thylacinidae	*Thylacinus potens*	-
	Thylacoleonidae	*Wakaleo alcootensis*	-
	Vombatidae	undetermined	-
	Diprotodontidae	*Pyramios alcootense*	-
		Alkwertatherium webbi	-
		Plaisiodon centralis	-
		Kolopsis torus	*Kolopsis torus*
		-	*Kolopsis yperus*
	Palorchestidae	*Palorchestes painei*	-
	Petauridae	*Pseudocheirops* sp.	-
	Macropodidae	*Hadronomas puckridgi*	-
		Dorcopsoides fossilis	cf. *Dorcopsoides*
		cf. *Dorcopsoides*	-
		Protemnodon sp.	-

virtue of their respective relatively high frequencies in the assemblage, so the apparent absence of *P. centralis* in the Ongeva LF is noteworthy. In terms of size and dentition, *K. yperus* and *P. centralis* are very similar and possibly occupied similar ecological niches, suggesting that (locally at least) the former species displaced the latter. A similar association between a large and small zygomaturine appears to have existed at Beaumaris, Victoria, where *Zygomaturus gilli* is found in association with a closely related but much smaller species. The small Beaumaris species is distinct from *Kolopsis torus* in having narrower molars, but could, as suggested by Rich (1976), represent another species of *Kolopsis*. The significance of these associations and possible successions are not understood, but might be related to the persistence of certain habitats adjacent to, or within, other more extensive regions undergoing rapid environmental change.

Of the taxa occurring at lower frequencies in the Ongeva LF, a small macropodid (cf. *Dorcopsoides*) is shared with the Alcoota LF. More generally, small animals are more poorly represented in the Ongeva LF than they are in the Alcoota LF. The ziphodont crocodylid, *Quinkana*, has not yet been determined in the Alcoota LF, and conversely *Baru* has not yet been determined in the Ongeva LF. Aquatic animals are rare in the Alcoota LF, and unknown in the Ongeva LF if one accepts *Quinkana* as a crocodylid adapted for life on land (Megirian 1994).

The Alcoota thanatocoenosis is characterised by intact bones showing little or no evidence of pre-burial weathering, a large number of individuals represented by associated skeletal elements (occasionally in partial articulation), short transport and rapid burial, and a notably high diversity of diprotodontid marsupials compared to any other Neogene assemblages. Murray and Megirian (1992) attributed mortality to a specific event, water-hole tethering during a drought, with subsequent rapid burial resulting from a drought-breaking flood, or several such close-spaced events, which mobilised large amounts of sediment and dumped it as poorly sorted, poorly bedded braided deposits. The local 'water-hole' was interpreted to be a lake, or series of small lakes some relatively short distance downstream from the fossil accumulation. The aquatic components of the Alcoota LF suffered less during the drought (as evidenced by the low frequency of skeletal remains), retreating with the lake waters to lower parts of the basin. A general lack of evidence for bone damage due to predation and scavenging was attributed to a temporary imbalance of the predator / scavenger (secondary consumer) guild with respect to the congregated primary consumers.

The Ongeva sediments, deposited after at least two extended periods of non-deposition are, in general, coarser than the Alcoota LF beds, though also poorly sorted. They contain more angular particles. The channel in the Ongeva section is relatively deeply incised, and bedding contacts within the fossiliferous sequence more clearly defined. Compositionally, the sediments appear quite similar. Bones of the Ongeva LF are completely disassociated from their skeletons and show a greater range of pre-burial alteration than is typical for the Alcoota LF. Even the most robust skeletal elements, such as dentaries and maxillae of mammals, and leg bones of the giant flightless birds, are rarely complete.

Damage to the ends of long bones in the Ongeva LF may have resulted from predator or scavenger damage, trampling, destructive transport, or a combination of factors. The rounding of many broken edges is probably due to the effects of hydraulic traction. Primary evidence for trampling in the Alcoota LF consists of bones crushed only in places, with the crushed bone becoming buried *in situ*. No such preservation has been recorded in the Ongeva LF, but breakage due to trampling can be assumed from herbivore coprolites deposited directly upon bones. No unambiguous evidence for predator and scavenger damage can be presented on the available material which preserves little surface detail. Significant, though patchy, contribution of small bone shards to the matrix of fossiliferous strata is a feature of the Ongeva LF beds: no comparable concentrations have been observed in the Alcoota LF beds. Their presence in the Ongeva LF suggests that some animal skeletons lay exposed on the surface long enough for the breakdown of collagen before burial of the remains. Compared to the Alcoota LF, large bones are even more disproportionately represented relative to smaller skeletal elements, a feature attributable to winnowing.

Few specimens per individual, and few individuals, are required to account for the yield of diagnosable Ongeva LF material. For example, using only skull fragments and disregarding relative stages of tooth wear, three individuals could minimally account for *K. torus* (e.g. three left dentaries); five individuals could account for *K. yperus* (three adult right maxillae, the holotype P^3+M^1 which do not match any of the maxillae, and a dentary of a juvenile); and one individual accounts for *Quinkana* sp.

There is nothing in the Ongeva LF to suggest a community under the degree of environmental stress, specifically drought, that led to the Alcoota LF thanatocoenosis. The coprolites indicate that conditions were tolerable for herbivores. An analogy can be made with the consistency and consequent depositional form of domesticated bovid excreta which varies according to the feed available. Where feed is succulent, excreta dropped from anal height splatters widely around the point of impact. At the other extreme, where feed is very dry and coarse, excreta tends to be hard and pelletal, with pellets surviving their fall without deformation. The intermediate form has a coherence that results in a well-rounded, regular pat with concentric rippling. The Ongeva coprolites most closely resemble this intermediate form, suggesting by analogy with cows, that conditions at the time of deposition were favourable, though perhaps towards the drier end of the scale, for bulk-feeding herbivores. Associated cow-sized taxa possibly responsible for coprolite deposition are the herbivorous / seed-eating giant flightless bird cf. *Genyornis stirtoni*, or one of the diprotodontid marsupials (more likely *Kolopsis yperus*, but *K. torus* cannot be ruled out). (In 1995, a large pelletal coprolite was collected from the Alcoota LF.)

The sedimentology of the Ongeva LF beds indicates a relatively more proximal part of an alluvial system compared to the Alcoota LF beds. On Hill 1, fossiliferous sediments are confined to distinct channels with cobble conglomerate basal lag. On the other hand, in the Alcoota quarries fossils are contained in more poorly defined, probably braided, channel deposits (typically pebble grade at their base), and in adjacent finer sediments (sand and silt grade) that possibly represent lateral accretion facies. The relative energies in the two systems account for many of the differences in bone size, sorting, and whatever damage can be attributed to traction noted above

The Ongeva LF is most likely to have resulted from natural attrition about a possibly seasonally flowing stream channel. Presumably between foraging, the animals were drawn from the local environs to small, permanent or semi-permanent pools, but not under the duress of an extended drought.

CONCLUDING REMARKS

There is evidence in the Waite Formation at Alcoota of tectonism, possible changes in stream gradients and/or direction, coarsening upwards of sediments, and depositional hiatuses marked by the effects of deep weathering. While the Alcoota LF beds (predominantly siltstone and sandy siltstone) are generally finer than the stratigraphically higher beds at Hill 1, they too are poorly sorted and contain lenses and channel fills of coarse (to pebble size) material. Murray and Megirian (1992) suggested on sedimentological and palaeontological grounds that these sediments represent distal fluvial to marginal lacustrine facies of an intermontane basin. Coarser channel facies higher in the section reflect more proximal fluvial characteristics. Woodburne (1967a) characterised this transition by sub-dividing the Waite Formation into a lower 'lacustrine' member and a higher 'fluviatile' member. The overall coarsening upwards of the succession, as well as the drop in compositional and textural maturity across the boundary of units III and IV, could be explained by a change in sediment provenance (derivation from sources closer to the point of deposition), increase in hydraulic gradients (due perhaps to tectonism or lake regression), change to drier climate (less chemical weathering and mechanical abrasion of particles during hydraulic traction), or some combination of factors. If the correlations between outcrops of Waite Formation proposed by Woodburne (1967) are correct, then deposition of the Alcoota and Ongeva Local Faunas predate folding at Hill 3. The evidence presented in Senior *et al.* (1995) for reversed (relative to present) stream drainage in the Waite Formation at Utopia, north of the study area, cannot be directly linked to indications of a change in sediment provenance preserved on Hill 1. However, both sets of observations point to phenomena producing changes in basin drainage during Waite Formation times.

The differences between the Alcoota and Ongeva LFs result from taphonomic and preservational biases, a range of palaeoenvironmental factors, as well as morphological evolution and faunal turnover over an unknown length of time. The Ongeva assemblage is more likely to have resulted from natural attrition around waterholes in seasonally flowing rivers than from a mass mortality due to extended drought such as that postulated by Murray and Megirian (1992) to have produced the Alcoota Local Fauna. Of the Zygomaturinae, *Kolpsis yperus* makes its appearance in the Ongeva LF, and may have displaced *Plaisiodon centralis* from the Alcoota Local Fauna. On the other hand, *Kolpsis torus* persisted.

Murray *et al.* (1993) attached biochronological significance to *K. yperus*, arguing that consistent with superpositional relationships, it represented a stage-of-evolution slightly advanced over Alcoota LF *K. torus*, approaching that of *Z. gilli* (Beaumaris LF, Victoria). New *K. yperus* material indicates that this taxon is somewhat closer to *Z. gilli* from the Cheltenhamian Stage of Victoria than previously supposed by Murray *et al.* (1993), and the two may be synonymous. The age difference between the Alcoota and Ongeva LFs time does not appear to be great. *Kolopsis torus* persisted from Alcoota to Ongeva LF time, with so little morphological change that a distinction of morphospecies, or even sub-species, cannot be justified.

Whatever the causes of the differences between the Alcoota and Ongeva Local Faunas, the two are biostratigraphically distinct.

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It is not our intention in naming so few to diminish the contributions to this work of our many friends, volunteers, colleagues, Flinders University students, and hosts at Alcoota. Mick Whitelaw most generously placed his resources and expertise in palaeomagnetics at our disposal. Our thanks to all.

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AUSTRALITES FROM THE NORTHERN TANAMI OF THE NORTHERN TERRITORY.

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ABSTRACT

A sample of five tektites (australites) from the northern Tanami Desert of the Northern Territory contributes to the definition of the strewn field in northern Australia. Two tektites are of the HMg (high magnesium) type, while three are of 'normal' composition. The sample lies on the projected depositional streak of HCa (high calcium) australites, but the absence of any specimens of HCa composition suggests that, unlike the HMg and 'normal' depositional areas, the HCa area does not extend into the northern part of the continent.

KEYWORDS: Tektites, australites, chemical composition, Tanami Desert, Northern Territory, Balgo, Western Australia, artefacts.

INTRODUCTION

Tektite glass produced by meteorite impacts occur in restricted geographical areas known as strewn fields. Tektites from Australia (australites) may be genetically related to those of Southeast Asia. The Southeast Asian tektites (philippinites, indochinites etc.) and australites are chemically quite similar (though not homogenous), consistently yield radioisotopic ages of formation of about 700-800,000 years before present, and show a directional gradient in average size and development of aerodynamic shapes. The Muong Nong (Indochina) type are layered, extremely irregular in size (up to several kilograms) and shape, and have no aerodynamic modifications. Australites are much smaller (rarely over 100 g) with unweathered examples noted for their well-developed aerodynamic symmetries and surface features. A number of possible impact sites have been identified in Indochina and as distant from Australia as central Asia (Kazakstahn) and Antarctica, some more likely than others, but the source of Australasian tektites has yet to be firmly established (Hartung and Koeberl 1994).

Determination of the extent of the australite strewn field is complicated by a range of factors which have resulted in tektite redistribution. Amongst them are erosional processes, transport by ground-dwelling birds who select them as gizzard stones, and transport by Aboriginals who used them as both a raw material for stone tool making and for ritual purposes, and who transported them across the continent (e.g. Cleverly 1976; Edwards 1966; Akerman 1975; Gould 1969).

The rarity of tektites in northern Australia and the often inadequate documentation of their occurrence meant that for a long time there were insufficient grounds for assuming that the strewn field extended north of about latitude 25°S (Fig. 1) (Cleverly and Dortch 1975; Chalmers *et al.* 1976). The discovery of tektites in Pleistocene stream gravels of the far north (Bow River and King George River), in stratigraphic settings containing no supporting evidence for a human involvement in their presence, eliminated residual uncertainties about the extent of the field (Mason 1986; Fudali *et al.* 1991).

Australian tektites are not a chemically homogenous group, but fall into a number of compositional classes which are confined to geographic regions (Taylor 1962; Taylor and Sachs 1964; Chapman and Schreiber 1969; Chapman 1971; Mason 1979, 1986, 1990). The cause or causes of this partitioning are not understood. Here we report on six tektite specimens, five from the northern Tanami Desert in the Northern Territory and one from near Balgo in Western Australia, for which we can provide an account of their recovery. These few specimens have a significance beyond their numbers because they come from an area remote from the nearest previously analysed collections (Fig. 1) and the sample contributes to the further definition of compositional regions.

Tektites were first reported from the Tanami by Jensen (1915) who reported that: "Mr William Laurie informs me that obsidian buttons are common about Bullock's Head - about 40 miles from Tanami on the Granite road." Cleverly (1976) doubted the report because it was "... hearsay unsupported by specimens and no confirmation has been forthcoming in the 60 years since the report was made." In 1992 and 1993, Mr Phil Smith of the Western Mining Corporation discovered two tektites in the Tanami in the course of mineral exploration, and showed them to Mr J. Emerson of Kalgoorlie, the Chief Driller. Mr Emerson borrowed them for inspection by Mr W.H. Cleverly, who immediately appreciated their significance. Mr Smith kindly donated them to the Northern Territory Museum (NTM), where they are now lodged. A subsequent search in July, 1995, on Tanami Downs by an NTM party lead to the recovery of three additional specimens from Bullock Head Lake. ('Bullock Head' appears to be the name applied to a general area, as well as figuring in the name of specific geographic features). The sixth specimen, from Jidirr near Balgo, West-

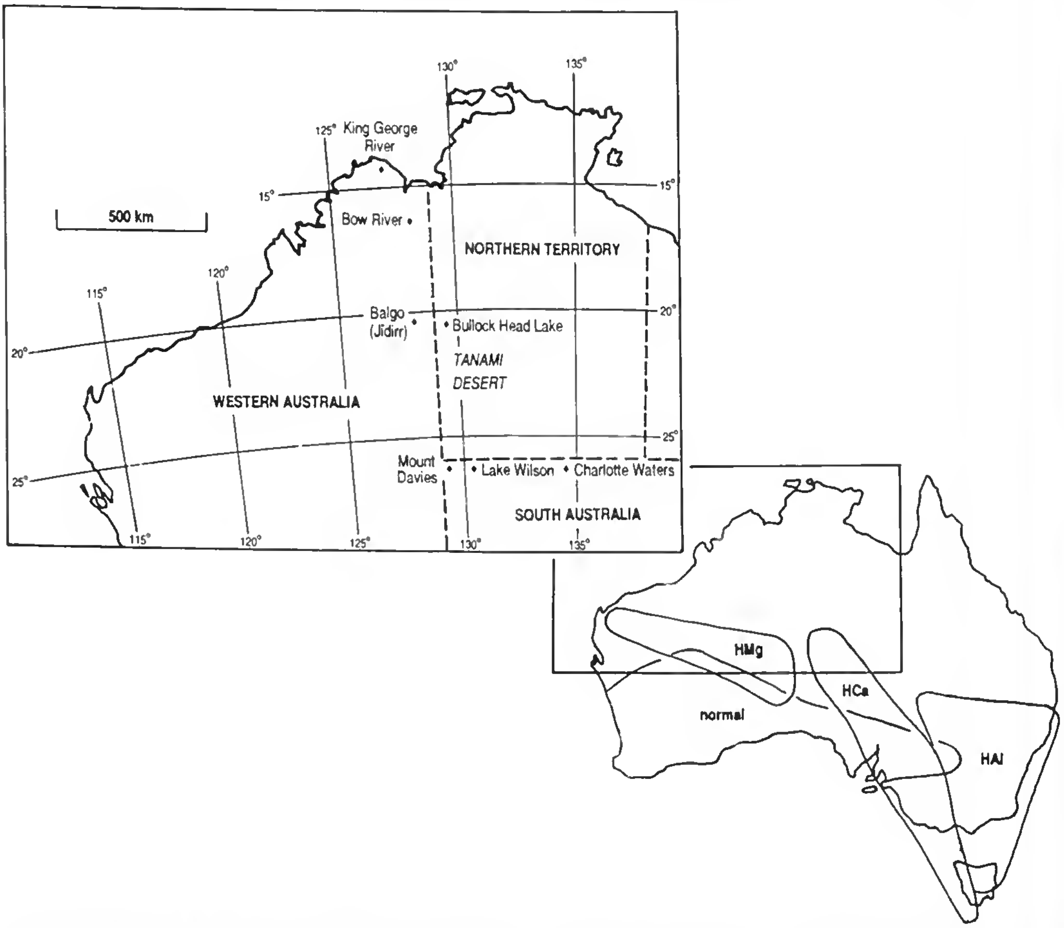

Fig. 1. Map showing localities mentioned in the text and the distribution pattern of HMg, HCa, HAl and 'normal' compositional classes of australite recorded by Chapman and Schreiber (1969) and Chapman (1971). The shown distributions give an impression of the extent of the australite strewnfield as it was generally accepted before the Bow and King George River finds. Note that 'normal' australites are a distinct class that has a restricted distribution within the strewnfield. (Distribution pattern after Chapman 1971: fig. 2).

ern Australia, was found in 1981 and presented to Mr K. Akerman who was accompanying its Aboriginal finder, Mr Richard Tax. The specimen is included here because Mason (1986) found no tektites in the Balgo area, and understood that they were not known by the Aboriginal inhabitants to occur there. Additional details are given below.

Materials and methods. Northern Territory Museum (NTM) **951** – Tanami Desert, Northern Territory, 20°25'S 129°46'E, coll. P. Smith, September 1992, round core, coarsely pitted followed by abrasion, diameter 18.2-20.2 mm, thickness 11.5 mm, 5.35 g, found in interdune area, on small (200 m diameter) claypan, sparsely covered by lateritic pebbles, no associated artefacts (P. Smith pers. comm., 13 November 1995). **952** - Tanami Desert, Northern Territory, 19°51'S 129°21'E, coll. P. Smith, October 1993, round core, coarsely pitted followed by abrasion, diameter 16.3 - 17.8 mm, thickness 9.7 mm, 3.30 g, found on lateritic pebble surface in area of first order streams, no associated artefacts (P. Smith pers. comm., 13 November 1995). **953** - Bullock Head Lake, Tanami Downs, Northern Territory, 20°25'S 129°11'E, coll. D. Megirian, 27 July 1995, irregular core, some coarse pits remaining after heavy abrasion and wind facetting, diameter 18.2 - 19.7 mm, thickness 11.4 mm, 5.28 g, found on pediment of lateritic pebbles, no associated stone artefacts. **954** - Bullock Head Lake, Tanami Downs, Northern Territory, 20°26'S 129°13'E, coll. D. Megirian, 27 July 1995, core, coarsely pitted followed by abrasion, diameter 13.2 - 14.5 mm, thickness 8.0 mm, 1.70 g, found on pediment of lateritic pebbles, no associated stone artefacts. **AA 95.9** - Bullock Head Lake, Tanami Downs, Northern Territory, 20°26'S 129°13'E, coll. P. Marianelli, 27 July 1995, tektite artefact (determination: K. Akerman), found on pediment of lateritic pebbles about 50 m southeast of 954. A scatter of artefacts was found at the base of a sand dune a further 50 m to the southeast, but the tektite artefact was not obviously part of this scatter. **9515** - Jidirr, Western Australia, 20°10'S 126°53'E, coll. R. Tax, 25 June 1981, round core, coarsely pitted followed by abrasion, diameter 15.0 mm, thickness 9.1 mm, mass 2.20 g, found amongst stone artefacts on sand dune (K. Akerman, field notes, 25 June 1981).

Table 1. Analyses of australites from the Tanami of the Northern Territory (951-954 incl. and AA 95.9), and Jiddirr, Western Australia (9515). Abbreviations: **R.I.**, refractive index: **S.G.**, specific gravity; - , not determined.

	951	952	953	954	9515	AA 95.9
SiO_2	70.4	70.7	69.9	71.9	70.2	-
Al_2O_3	13.1	13.3	12.4	11.9	13.8	-
FeO	5.00	4.95	6.33	5.27	4.94	-
MgO	2.96	2.90	4.10	3.15	2.63	-
CaO	4.01	3.69	2.99	2.98	3.05	-
K_2O	2.05	2.08	2.04	2.29	2.45	-
Na_2O	1.14	1.23	1.15	1.15	1.46	-
TiO_2	0.73	0.72	0.71	0.70	0.81	-
MnO	0.11	0.12	0.15	0.15	0.10	-
Sum	99.5	99.7	99.7	99.5	99.5	-
S.G.	2.457	2.455	2.473	2.446	2.455	2.456
R.I.	1.515	1.515	1.520	1.513	1.515	1.515
mass (g)	5.34	3.30	5.28	1.70	2.20	0.17

The australites were analysed by microprobe using the technique and standards of Mason (1979), and the results are given in Table 1. The artefact AA95.9 has the same specific gravity and refractive index as 951, 952 and 9515 and was therefore not analysed by microscope.

DISCUSSION AND CONCLUSIONS

Chemical analysis (Table 1) shows that two of the Tanami tektites, 953 and 954 (the two specimens from Bullock Head Lake), plot with Chapman's (1971) HMg (high magnesium) group (Fig. 2), compositionally matching those from Mt Davies and Lake Wilson (Mason 1979). Chapman and Schreiber (1969) recorded the HMg group as occupying central Western Australia and adjacent areas in South Australia and the Northern Territory (Fig. 1), but the compositional region has since been extended into northern Western Australia to include Kimberley finds (Mason 1986, 1990; Fudali *et al.* 1991). The other tektites (951, 952 and 9515) are, in Chapman's classification, 'normal' australites, a chemically quite homogenous class with a confined distribution. (Mason (1979) found that none of the 'normal' australites he analysed contain more than 2.40 % MgO, and we observe that if this threshold is applied, then all the australites reported here fall into the HMg class.)

The Tanami finds lie on the projection of the streak of HCa (high calcium) tektites which extends from western Tasmania through to Charlotte Waters in northern South Australia. No HCa samples are present in the Tanami assemblage, suggesting that this class does not extend northwards much beyond Charlotte Waters.

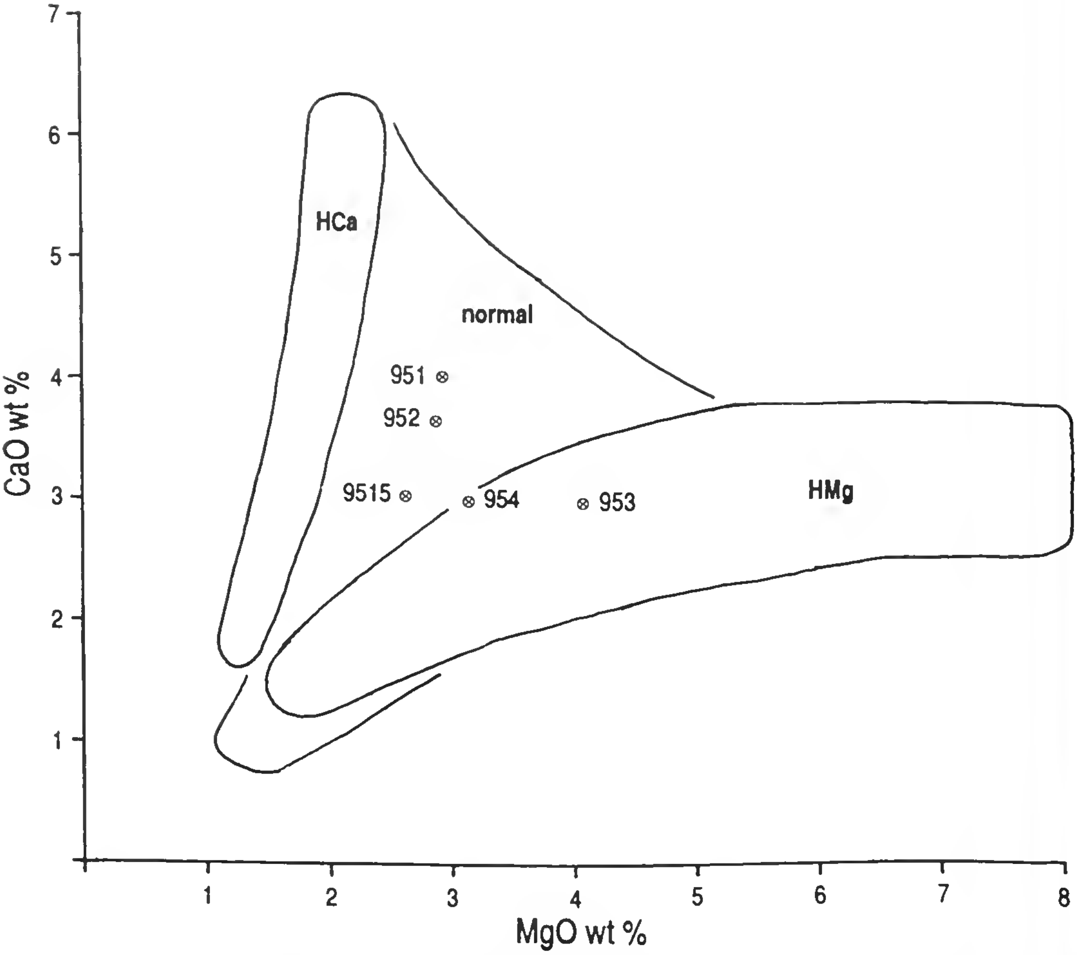

Fig. 2. Bivariate plot of CaO against MgO, showing the Tanami samples in relation to the compositional fields of HMg, HCa and 'normal' australites. (After Chapman and Schreiber 1969: fig. 2).

A criterion suggested by Cleverly (1976: 233) as a 'reliable' indicator of the extent of the strewn field is: '... multiple (≥10) tangible specimens with flakes constituting a small minority...'. The specimens reported here are isolated finds, with only two having been found in proximity. Only the Western Australian specimen was found within an artefact scatter. One of the Tanami specimens is itself an artefact, but the remainder were not obviously associated with artefacts or other tangible evidence of human activity. The relatively small range of chemical variation within the sample (in spite of the tektites falling into two compositional classes) and the nature of the occurrences warrants their provisional use as strewn field indicators.

The two intact Bullock Head Lake specimens (953, 954) were found at the end of a more extensive search on Tanami Downs, on a lateritic pebble surface that may represent an ancient land surface exhumed quite recently (geologically speaking) by dune retreat (Fig. 3). The surface may be an exposure of a laterite mapped as Tl on the 1:250,000 geological sheet of the area (SF 52-3, The Granites). Tl is extensive around Bullock Head, and further searching of it is warranted to establish whether tektites occur on it with sufficient frequency, as William Laurie's communication to Jensen (1915) might suggest, to provide a more 'reliable' sample with which to test our findings. Members of the Tanami Downs Aboriginal community are familiar with tektites, which were referred to as 'black gold', but they have not found any in that part of country, though they keep an eye out for them when they are out hunting.

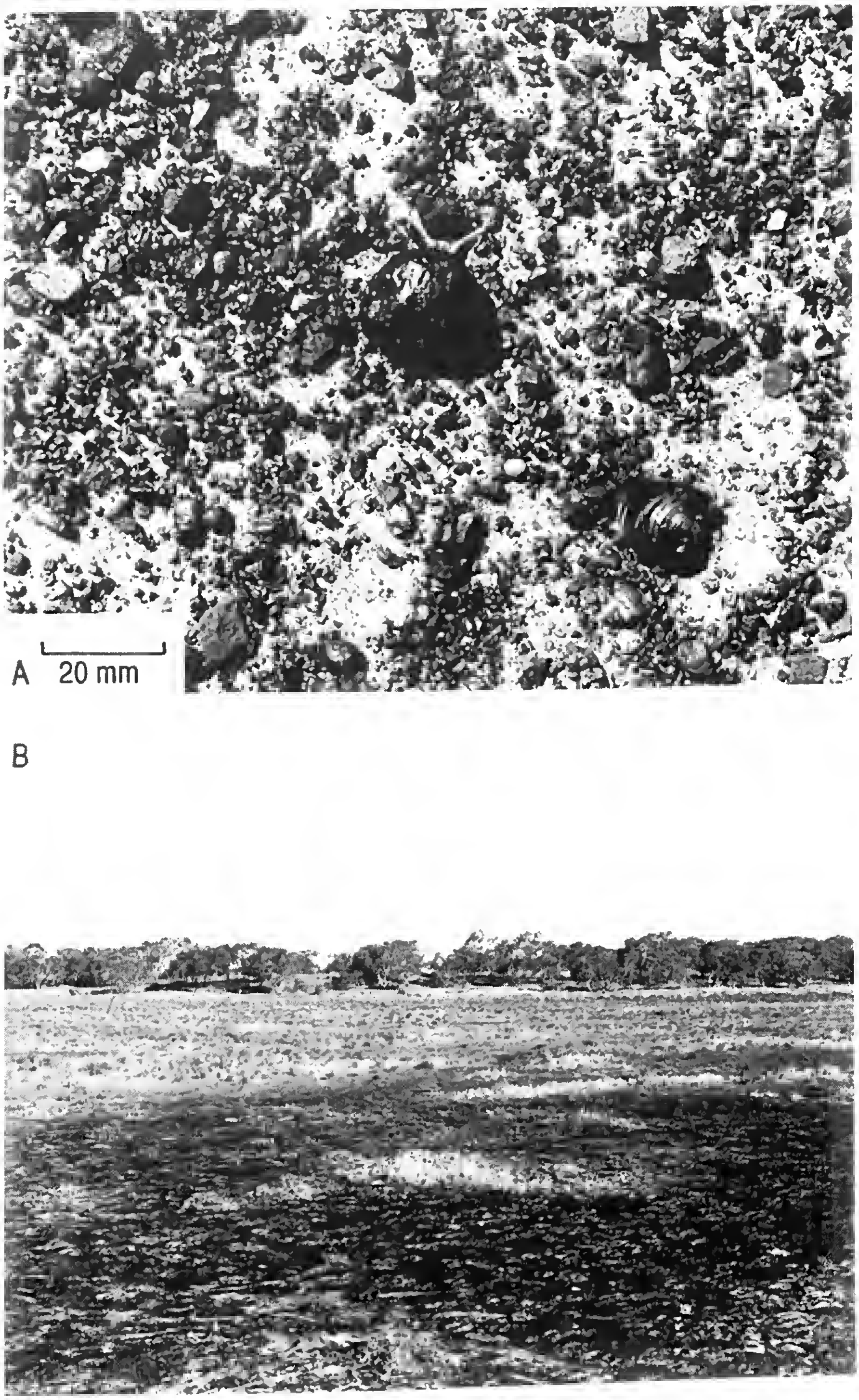

Fig. 3. A, specimen 954 (centre) and the artefact AA95.9 (lower right quadrant) replaced (i.e. not *in situ*) on the lateritic pebble surface at Bullock Head Lake on which they were found, some 50 m apart. **B**, find site of 953 (foreground), near Bullock Head Lake. The flat ground possibly represents an ancient land surface exhumed by deflation of the sand dune in the background.

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A NEW SPECIES OF *EGGLESTONICHTHYS* (TELEOSTEI: GOBIIDAE) FROM THE INDO-WEST PACIFIC, WITH DISCUSSION OF THE SPECIES OF THE GENUS.

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ABSTRACT

A new species of the gobiid genus *Egglestonichthys* Miller and Wongrat is described from three specimens collected by trawl from the Arafura Sea and Van Diemen Gulf, northern Australia, and off Bombay, India. *Egglestonichthys melanoptera* (Rao), originally assigned to *Callogobius*, is re-described. The new species differs from *E. melanoptera* and *E. patriciae* in having very small eyes, a more narrow gill opening, and distinct brown bands and saddles on a pale background.

Keywords: Gobiidae, Gobiinae, Indo-Pacific, taxonomy, new species, *Callogobius, Egglestonichthys*.

INTRODUCTION

In 1977, Northern Territory (NT) Fisheries personnel collected an odd-looking banded gobiid fish from Finke Bay in the Van Diemen Gulf, NT. The junior author recognised it as a possible new genus while examining the NT Fisheries collection in 1978; the specimen was subsequently donated to the Australian Museum.

Further examination of this specimen indicated that the fish belonged in the monotypic genus *Egglestonichthys* Miller and Wongrat, 1979, although differing in having very fleshy sensory papillae raised into ridges around the snout and jaws (as in the genus *Callogobius* Bleeker), fewer lateral line scales and a distinctive colour pattern. A second specimen was eventually found, in 1981, among prawn-trawl by-catch aboard the FV *Anson*, off the Cobourg Peninsula, NT. A third specimen was found among the Zoological Museum, Copenhagen, collection, taken in 1964 south-west of Bombay. Miller and Wongrat (1979: 252) referred to this specimen (as "an undescribed gobiid"), and considered that it was similar to *Egglestonichthys* and *Callogobius* because of its papillose ridges, fine scalation on the head and snout, and enlarged canine teeth, but could be distinguished from either genus by means of its "greatly reduced eyes".

The type of *Callogobius melanoptera* Rao, was suspected to be an *Egglestonichthys*. The putative holotype (ZSI 7919/2) and four other *C. melanoptera* (from New Guinea, the Philippines and Vietnam) were examined and found to belong to a valid species of *Egglestonichthys*, which is here redescribed.

Abbreviations used are: AMS: Australian Museum, Sydney; BMNH: Brirish Museum of Natural History, London; NTM: Museum and Art Gallery of the Northern Territory, Darwin; RUSI: J.L.B. Smith Institute of Ichthyology, Grahamstown; USNM: National Museum of Natural History, Washington; ZMK: Zoological Museum, Copenhagen; ZMUC: Köbenhavns Universitets Zoologisk Museum , Copenhagen; ZSI: Zoological Survey of India, Calcutta; SL: standard length; TRB: transverse scale count backward from anal fin origin; TRF: transverse scale count forward from anal fin origin.

SYSTEMATICS

Egglestonichthys Miller and Wongrat

Egglestonichthys Miller and Wongrat, 1979: 240-242 (type species *E. patriciae* Miller and Wongrat, 1979, by original designation and monotypy).

Fig. 1. *Egglestonichthys bombylios* n.sp., male holotype, NTM S. 10031-016, 45 mm SL.

Egglestonichthys bombylios n. sp.
(Figs 1-3, Table 1)

Type material. HOLOTYPE - NTM S.10031-016, 45 mm SL male, N of Smith Point, NT, 29 m, coll. H.K. Larson on FV *Anson*, 18 October 1981. PARATYPES - AMS I.25055-001, 55 mm SL female, Finke Bay, Van Diemen Gulf, NT, coll. NT Fisheries, 27 October 1977; ZMUC P.781840, 44 mm female, about 26 km SE of Bombay, 12 May 1964.

Diagnosis. A robust goby with very small eyes, upturned mouth and conspicuous colour pattern; second dorsal rays I,9-10; anal rays I,9-10; pectoral rays 20-22; longitudinal scales 31-35; TRB 13-14; head covered with scales, predorsal scales small, extending down to nostrils, opercles scaled, cheeks scaled on upper half; scales on sides of body ctenoid (ctenii deciduous); eyes very small and lateral; interorbital very broad and convex; jaws supraterminal, with outer row of enlarged teeth on lower jaw protruding outside lips; head pores absent; transverse papillae pattern on head, papillae large and fleshy, some rows raised, forming ridges; five broad brown bands or saddles across interorbital, nape and sides, background colour pale whitish or yellowish.

Table 1. Meristics of type specimens of *Egglestonichthys bombylios* n. sp.

Character	Holotype NTM S.10031-016	Paratype AMS I.25055-001	Paratype ZMUC P.781840
Standard length	45	55	44
First dorsal rays	VI	VI	VI
Second dorsal rays	I,9	I,10	I,10
Anal fin rays	I,9	I,10	I,10
Pectoral fin (R/L)	20/21	21/21	22/22
Transv. rows back.	13	14	15?
Trans. rows forward	16	17	?
Lateral line scales	31	35	?
Predorsal scales	30	33	30
Circumped. scales	22	?18	?21
Caud. rays (seg.)	9/8	9/8	9/8
Caud. rays (branch.)	7/6	7/6	7/6

Description. Based on three specimens, 44-55 mm SL. Counts and morphometrics of holotype, if differing from paratypes, indicated by asterisk (in parentheses where necessary).

First dorsal VI*; second dorsal I,9*, I,10; anal I,9*, I,10; pectoral rays 20*-22, segmented caudal rays 17*; caudal ray pattern 9/8*; branched caudal rays 7/6; unsegmented (procurrent) caudal rays 7/7 (in one specimen); longitudinal scale count 31*-35; TRB 13*-14; predorsal scale count 30-33 (31*); circumpeduncular scales 18-22*. Gill rakers on outer face of first arch 4+14*, 5+13, 5+16; pterygiophore formula 3-22110 (in all specimens). Vertebrae 10+16 (in all specimens). One epural in holotype, two in Finke Bay paratype; Bombay paratype apparently with two epurals (indistinct in radiograph). Three anal pterygiophores before haemal spine of first caudal vertebra.

Head rounded in cross-section, length 3.1-3.5 (3.3*) in SL. Depth at posterior preopercular margin 1.4-1.5* in HL. Width at posterior preopercular margin 1.2*-1.5 in HL. Mouth supraterminal, oblique, forming an angle of 45-60° with body axis; jaws reaching to below anterior margin or part of eye. Lips smooth, lower lip free only half-way along jaw. Upper jaw 2.3-2.5* in HL. Eye very small, placed laterally and close to snout tip, 8.8-12.8 (9.0*) in HL. Snout broad and short, 3.0-3.3 (3.1*) in HL. Interorbital very broad and convex, 2.1-2.6 (2.5*) in HL. Body robust, compressed posteriorly, depth at anal origin 4.3*-4.6 in SL; body width at origin of first dorsal 6.0-6.3 (6.2*) in SL. Caudal peduncle length 4.2-4.6 (4.5*) in SL. Caudal peduncle depth 8.2*-8.6 in SL.

No mental fraenum; two longitudinal rows of fleshy papillae extending over chin to very edge of lower lip. Anterior nostril a broad, short tube,

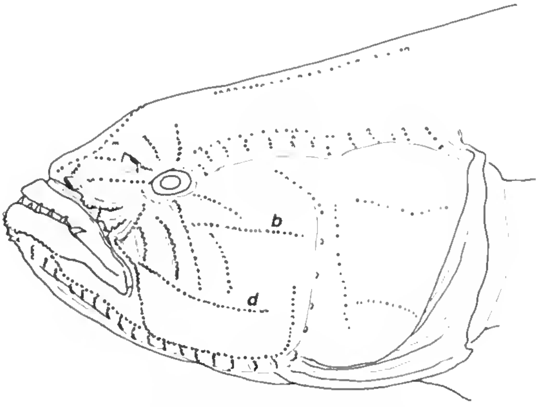

Fig. 2. *Egglestonichthys bombylios* n.sp., holotype, NTM S. 10031-016, showing sensory papillae pattern (scales omitted); sensory papillae rows *b* and *d* are indicated.

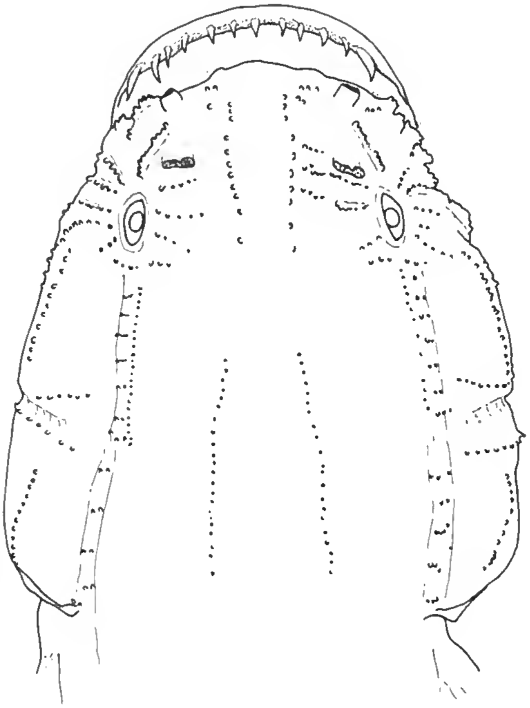

Fig. 3. *Egglestonichthys bombylios* n.sp., holotype, NTM S. 10031-016, dorsal view of head showing papillae (scales omitted).

close behind upper lip. Posterior nostril a broad slit above and forward of anterior margin of eye. Skin between nostrils naked (some scales present on either side of nostrils). Gill opening narrow, extending forward to under opercle, but not quite reaching to below posterior preopercular margin. Anterior edge of shoulder girdle (cleithrum) smooth. Gill rakers on outer face of first arch without spines, thin and slender, shorter than middle gill filaments; rakers on inner face of first arch short, stubby, with fine spines at tip and partly along inner face, outer rakers on other arches stubby, with fine spines at tips. Tongue blunt to rounded, ZMUC specimen with small notch at centre.

Outer row teeth in upper jaw enlarged, stout and curved; largest three or four teeth on either side of symphysis. Behind outermost row, dense band composed of five to six slender sharp backward-pointing teeth; teeth relatively straight to slightly curved; band of teeth widest toward centre of jaw. Lower jaw with outer row of seven to nine widely-spaced, large stout curved teeth; teeth larger toward sides of jaw; last tooth (at midside of jaw) angled out and backward; outer row teeth all protruding over upper lip when jaws closed. Behind outer row, an even band of two to four rows of small sharp upright teeth. An innermost row of larger, stout teeth; teeth evenly sized and tending to point backward.

Predorsal scales small, cycloid on sides and ctenoid dorsally (ctenii fall off easily; only clearly visible in holotype), reaching forward to between nostrils, ending at level of anterior nostril in largest specimen. Operculum covered with small cycloid scales. Cheek with cycloid scales behind eye and at least halfway down sides, never extending past papilla row *d*. Pectoral base with cycloid scales. Prepelvic area fully covered with cycloid scales, extending up to insertion of gill membranes. Belly and lower sides of body with cycloid scales. Ctenoid scales (ctenii quite long, but deciduous; largest specimen appearing as though all scales cycloid) on side of body.

Head pores absent, as in other species of the genus.

Sensory papillae pattern on head transverse, as in Figures 2 and 3. Papillae on head fleshy, most papillae slender; papillae on interorbital, jaws and snout areas especially are on raised fleshy ridges.

Genital papilla in male slender, flattened, narrowing slightly toward tip; tip with slender lobe at each side. Genital papilla in females short, bulbous, slightly flattened (may be preservation artefact), without lobes at tip.

First dorsal fin low and relatively rounded, spines barely reaching second dorsal fin origin when fin depressed, depressed dorsal 4.7-6.3* in SL. Second dorsal and anal fins pointed posteriorly, posteriormost rays of these fins not reaching caudal base when depressed. Pectoral fin relatively narrow, pointed, 3.8*-4.2 in SL. Pectoral rays branched, upper and lowermost one or two rays unbranched. Pelvic fins oval, disc-shaped, fraenum thin with margin ragged in holotype (possibly damaged); length 4.3*-5.1 in SL. Caudal fin narrow and short, rear edge rounded, 3.5-3.9 (3.6*) in SL.

Colouration of fresh material. No notes were taken when the holotype was collected, but the senior author recalls it as being pale yellowish, with dark brown bands.

Colouration of preserved material. Based on the holotype and larger AMS paratype, as these specimens still have their skin fairly intact. The colour pattern superficially resembles that of the stargazer, *Ichthyoscopus fasciatus*.

Background colour whitish, with six brown saddles and bars crossing back; first bar across eyes and sixth around caudal base. Anteriormost brown bar crossing from eye to eye, extending halfway down cheek; dorsally, bar not much greater than eye width in holotype, anterior margin curving forward to last few scales on snout in paratype (no brown colour on areas between anterior and posterior nostrils). Second bar or saddle crossing nape above opercle, width of saddle equals width of upper part of opercle, bar ending halfway down opercle on both specimens. Third saddle crossing back at first dorsal fin base, saddle width equal to base of fin; saddle narrowing and ending at level of mid-pectoral base. Fourth saddle crossing back below second dorsal fin (closer to rear of fin than to origin); saddle not narrowing ventrally but ending at about mid-side of body. Fifth and sixth bars encircling caudal peduncle, both bars close together and joined by mid-lateral brown stripe (one scale wide); sixth bar crossing caudal fin base at posterior edge of hypural and fifth bar about three scale widths anterior to it.

First dorsal fin plain dark brown, with relatively unpigmented distal margin. Second dorsal fin whitish anteriorly, most of fin dark brown (an extension of fourth saddle); posteriormost two rays and their membranes unpigmented. Caudal, anal, pectoral and pelvics whitish to translucent.

Distribution. Coastal waters of northern Australia ("Top End" of the Northern Territory) and western India (off Bombay).

Ecology. The NT specimens were trawled from soft mud substrates (banana-prawn grounds) in 2-29 m depths.

Remarks. All specimens are slightly the worse for wear after being trawled. The holotype is in the best condition; it is the only specimen with intact sensory papillae. The ZMUC specimen has had its skin badly abraded; Miller and Wongrat apparently thought it resembled a *Callogobius* in having an oculoscapular canal (which the specimen lacks).

Etymology. *Bombylios*: the Greek word for "bumblebee" (masculine), which this species resembles in colour pattern and (less so) in its robust body shape.

Egglestonichthys melanoptera (Rao)
(Figs 4-5, Table 2)

Callogobius melanoptera Rao, 1971: 44-45 (Godavari estuary).

Material examined. Holotype of *Callogobius melanoptera*: ZSI 7919/2, female, creek, Godavari estuary, coll. V.V. Rao. USNM 263565, 88 mm SL female, Carigara Bay, Samar Sea, Philippines, 50-70 m, coll. C. Ferraris, February 1980; RUSI 17279, 2 females (68-83), Vietnam, coll. P. Fourmanoir, 20 January 1964; AMS I.35825-001, 83 mm female, Orokolo Bay, Gulf of Papua, Papua New Guinea, coll. P.N.G. Department of Primary Industry, 25 September 1976.

Diagnosis. A relatively large goby with elongate, pointed black fins and plain dark brown head and body; second dorsal rays I,10; anal rays I,8-9; pectoral rays 21-22; pelvic fins fused but fraenum absent; longitudinal scales 35-45; TRB 12-14; head covered with scales, predorsal scales small, extending down to nostrils, opercles scaled, cheeks fully scaled; scales on body and most of head ctenoid (ctenii deciduous); eyes large, placed dorsolaterally; jaws nearly supraterminal, oblique, with outer row teeth protruding outside lips; head pores absent; transverse papillae pattern on head, papillae large and fleshy.

Description. Based on five specimens, 68-88 mm SL.

First dorsal VI; second dorsal I,10; anal I,8-9; pectoral rays 20-22, segmented caudal rays 17; caudal ray pattern 9/8; branched caudal rays 8/7; unsegmented (procurrent) caudal rays 7/6 (in one specimen); longitudinal scale count 35-45; TRB 12-14; predorsal scale count 29-37; circumpeduncular scales 14-16. Gill rakers on outer face of first arch 3+15 (in two specimens), 5+15 (in one), 5+16 (in one). Pterygiophore formula 3-22110 (in three). Vertebrae 10+16

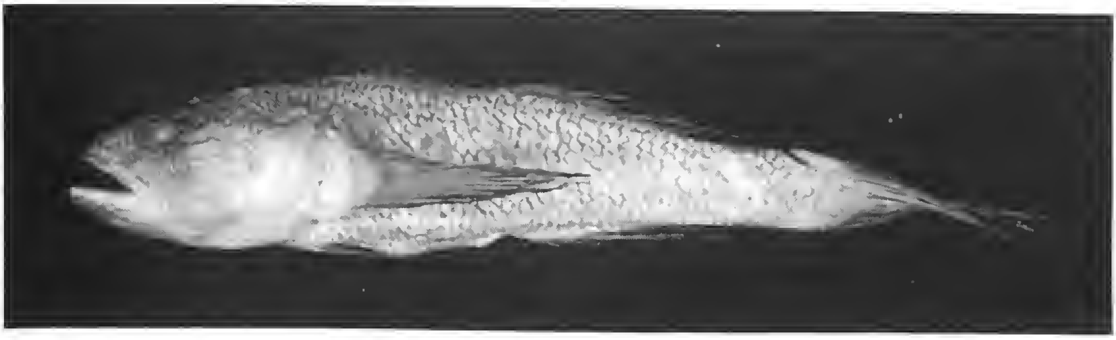

Fig. 4. *Egglestonichthys melanoptera*, AMS I.35825-001, 83 mm SL female.

(in three). One epural (in three). Two (in two) or one (in one) anal pterygiophores before haemal spine of first caudal vertebra.

Head rounded to almost square in cross-section, length 3.3-3.7 in SL, with broad cheek. Head depth at posterior preopercular margin 1.4-1.6 in HL. Head width at posterior preopercular margin 1.2-1.4 in HL. Mouth nearly supraterminal, oblique, forming an angle of 45-60° with body axis; jaws reaching to below mid-eye. Lips narrow, smooth, lower lip free just past half length of jaw. Upper jaw 2.0-2.2 in HL. Eye large, rounded, placed dorsolaterally (more dorsal than lateral), 3.8-4.5 in HL. Snout short, with pronounced knob in midline formed by ascending processes of premaxillae, 3.9-4.3 in HL. Interorbital moderately broad and flat, 4.9-5.9 in HL. Body rather compressed (possibly exaggerated by damage), depth at anal origin 4.4-4.9 in SL; body width at origin of first dorsal 6.3-9.4 in SL. Caudal peduncle length 3.9-4.5 in SL. Caudal peduncle narrow, depth 5.8-9.2 in SL.

No mental fraenum; two longitudinal rows of papillae extending over chin to very edge of lower lip. Anterior nostril a broad, short tube, close behind upper lip. Posterior nostril a broad slit (low rim may be present, although variably squashed in specimens examined) close to anterior margin of eye. Skin between nostrils naked (some scales present on either side). Gill opening wide, extending forward to below posterior margin of eye. Anterior edge of cleithrum (shoulder girdle) smooth. Gill rakers on outer face of first arch with stout spines along inner face, rakers relatively thin and slender, shorter than gill filaments; rakers on inner face of first arch short, stout, with spines at tip and along inner face, outer rakers on other arches similar, with spines at tips. Tongue blunt in three specimens, or rounded (in one).

Outer row teeth in upper jaw enlarged, stout, curved and relatively widely spaced; largest teeth toward front of jaw; teeth protruding outside lips when mouth closed. Behind outermost row, two to four rows of small sharp teeth, and an innermost row composed of larger sharp backward-pointing teeth; this inner row variably developed, most obvious at front of jaw. Lower jaw with outer row of widely-spaced, large stout curved teeth along front half of jaw only; teeth protruding over upper lip when jaws closed.

Table 2. Meristics of specimens of *Egglestonichthys melanoptera*.

Character	Holotype ZSI 7919/2	AMS I.35825-001	DPI Kanudi (uncat.)	USNM 263565	RUSI 17279	RUSI 17279
SL	65	83	84	88	68	83
First dorsal	VI	VI	VI	VI	VI	VI
Second dorsal	I,10	I,10	I,10	I,10	I,10	I,10
Anal	I,9	I,9	I,9	I,8	I,9	I,9
Pect. fin (R/L)	22/-	20/21	20/21	21/21	21/22	22/21
TRB	-	12	14	14	14	14
TRF	-	14	15	17	16	16
Lateral line	?35	40	41	45	35	35
Pred. scales	-	29	32	37	?31	32
Circum. sc.	-	15	18	14	16	15
Caud. (seg.)	17	9/8	9/8	9/8	9/8	9/8
Caud. (br.)	-	8/7	8/7	8/7	8/7	8/7

Behind outer row, an even band of four or five rows of small sharp upright teeth. An innermost row present of larger, stout curved teeth; teeth very similar in size and shape to outermost row, but tending to be evenly sized and all pointing backward.

Body scales ctenoid (most scales lost and remainder with most ctenii fallen off). Predorsal scales not much smaller than body scales, mostly ctenoid, reaching forward past nostrils, ending just behind upper lip; scales cycloid from level of posterior nostril forward. Operculum covered with scales (few remaining scales ctenoid). Cheek completely covered with scales, some scales ctenoid (remainder appear cycloid, but probably due to loss of ctenii); scales extending down past corner of mouth. Pectoral base fully scaled (scales lost, therefore unable to determine if cycloid or ctenoid). Prepelvic area fully scaled (scales lost), anteriorly to gill membranes insertion, and posteriorly to pelvic ray bases. Belly fully scaled (scales lost).

Head pores absent, as in other species of the genus.

Sensory papillae pattern on head transverse, as in Figure 5. Papillae on head fleshy, most papillae slender (difficult to see due to trawl damage).

Female genital papilla quite bulbous, with two lobes on either side of tip; papilla of probable male (Papua New Guinea) specimen conical, slightly flattened, no lobes at tip visible.

First dorsal fin pointed, second to fourth spines longest, spines reaching third or fifth second dorsal fin elements when fin depressed, depressed dorsal 3.7-3.8 in SL. Second dorsal and anal fins pointed posteriorly, posteriormost rays of these fins not quite reaching caudal base when depressed. Pectoral fin long and narrow, pointed, reaching past anal fin origin, 2.4-2.8 in SL. Pectoral fin with uppermost and lowermost rays unbranched. Pelvic fins somewhat pointed, forming flat disc (membrane joining fifth rays broken in all specimens, but present and undoubtedly continuous), fraenum absent with no remnant present on base; length 3.2-4.2 in SL. Caudal fin long, narrow and pointed, longest rays in centre of fin; 1.8-2.0 in SL.

Coloration of fresh material. No information available.

Coloration of preserved material. All specimens have variably damaged skin; the Papua New Guinea specimen being in the best condition. Fish appear to be plain dark brown all over head and body, darkest dorsally. All fins black to dark brown; pelvics lighter brown than other fins.

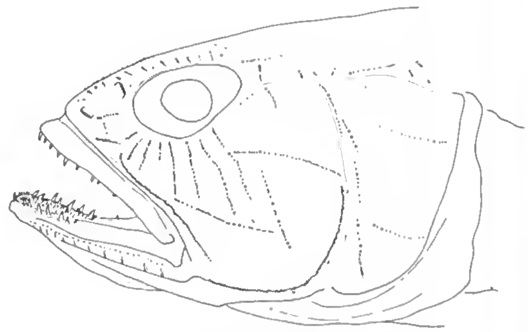

Fig. 5. *Egglestonichthys melanoptera.* AMS I.35825-001, 83 mm SL female, head papillae pattern (specimen abraded, some papillae probably missing).

Distribution and ecology. Known so far only from the Godavari estuary, eastern India (this river has many mouths); Vietnam (no details available); the Samar Sea, Philippines (the Samar Sea is virtually enclosed by the islands of Samar, Leyte and Masbate); and Orokolo Bay, Gulf of Papua, Papua New Guinea.

Remarks. From the junior author's notes and the original description, the holotype has a narrower gill opening than other specimens examined (extending to below preopercular edge, not to rear of eye).

This species looks rather like *E. patriciae*, but the pelvic fraenum is completely absent. Winterbottom and Burridge (1992) indicate that the lack of fraenum is usual (but not a constant) in species of *Priolepis*.

Egglestonichthys patriciae Miller and Wongrat

Egglestonichthys patriciae Miller and Wongrat, 1979: 242-246 (South China Sea).

Remarks. Miller and Wongrat's 1979 original description is fairly detailed but does not give any transverse (or circumpeduncular) scale row counts (approximately 14 TRB rows are visible on their drawing on p.245). Winterbottom and Burridge's (1992) description of this species was based largely on Miller and Wongrat, as the holotype (and only known specimen) has been alizarin-stained and partly dissected, with the left half of the jaw, suspensorium, pectoral base and pectoral fin missing.

Material examined. Holotype of *Egglestonichthys patriciae*: BMNH 1979.4.25.1, 47 mm

SL male, about 325 km SE of Hong Kong, Granton trawl over muddy sand, 79 m depth, 3 April 1967.

DISCUSSION

Winterbottom and Burridge (1992) consider *Egglestonichthys* as a sister-group to *Priolepis* or possibly a group which included genera such as *Trimma, Trimmatom* and *Paratrimma*. This suggestion was based on these genera all sharing the characters of: absence of lateral canals and pores on the head, possession of a wide gill-opening extending forward to below the rear margin of the preopercle, vertical dark-margined bars often present on the head and body (*Egglestonichthys bombylios* and *E. patriciae* have some dark barring, but all available specimens of *E. melanoptera* appear to be plain blackish), and denticles present on the inner face of the gill rakers on the outer face of the first gill arch. The last character is given as an apomorphy for the genus *Priolepis* by Winterbottom and Burridge (1989). However, these tiny spines on the first arch rakers may be found in some small commensal gobiines such as *Bryaninops* (Larson 1985), some species of *Pleurosicya* and *Lobulogobius* (Larson and Hoese 1980; Larson 1990), at least one species of the shrimp commensal *Amblyeleotris*, and eventually may be found in other taxa upon further examination. Within *Egglestonichthys*, there is variation in gill raker spination, as the spines are absent in *E. bombylios* but present in *E. melanoptera* and *E. patriciae* (the latter with one spicule only on the first raker, according to Winterbottom and Burridge 1992). Winterbottom and Burridge (1989) refer to the small species *Aphia minuta* possibly having spines on the first gill arch, based on an illustration. Northern Territory Museum specimens of this species (from Plymouth, England) have no spines on the first arch rakers (however, the specimens do have the gill filaments reduced considerably on the lower limb of the first arch, so that the filaments look as though they have been artificially trimmed, which may be a useful character in diagnosing the genus).

Pelvic fin fraenum and fin form varies among the three species of *Egglestonichthys*: *E. patriciae* has a distinct fraenum, *E. bombylios* has a very thin one and *E. melanoptera* has none. *Priolepis* species often have no fraenum (Winterbottom and Burridge 1992).

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Our thanks to Phil Heemstra (RUSI), Susan Jewett (USNM) and Jorgen Nielsen (ZMUC) for the loan of specimens from their collections and information about them. Thanks are also due to Alan Watt, of the FV *Anson*, who allowed the senior author to sort through 24 hours of banana prawn by-catch to find the holotype of *E. bombylios* (and other new species). Rex Williams photographed the specimens.

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A NEW SPECIES OF *RAMPHOTYPHLOPS* (SQUAMATA: TYPHLOPIDAE) FROM THE DARWIN AREA, WITH NOTES ON TWO SIMILAR SPECIES FROM NORTHERN AUSTRALIA.

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ABSTRACT

A new species of *Ramphotyphlops* is described from the Darwin area, northern Australia. It differs from all other *Ramphotyphlops* in the combination of 16 midbody scale rows with a high number of ventral scales. Additional records of *R. minimus* (Kinghorn, 1929) are reported, including the first record from mainland Australia. *Ramphotyphlops guentheri* (Peters, 1865) shows discontinuous geographically-linked variation in number of ventral scales. The name *R. nigricauda* (Boulenger, 1895) is applicable to the eastern form, while *R. guentheri* applies to the western form.

Keywords: Squamata, Typhlopidae, *Ramphotyphlops*, new species, Darwin, Northern Territory, Australia.

INTRODUCTION

The family Typhlopidae, represented by the genus *Ramphotyphlops*, remains among the least studied and most poorly known elements of the Australian herpetofauna, both taxonomically and ecologically. The most recent taxonomic treatment of the family throughout Australia is by Waite (1918), although Storr (1981) revised the Western Australian members of the family. One of the major deficiencies in knowledge is the systematics and distribution of the family in northern Australia. This deficiency is primarily due to the serendipitous nature of typhlopid collections in a region of sparse settlement, resulting in small scattered samples. For example, Waite (1918) had material from only 28 localities north of the Tropic of Capricorn (23°30'S), while over half a century later, Storr (1981) had only eight specimens from the north Kimberley. Despite this paucity of material, it is becoming apparent that northern Australia is a major centre of diversity for typhlopids. Of the 34 species of Australian *Ramphotyphlops*, 22 species occur in tropical Australia, and 17 species are restricted to that zone. This latter number includes nine of the 15 species described since Waite's (1918) revision.

This paper describes another new species of *Ramphotyphlops* from northern Australia, provides data on distribution and morphology of two similar species, *R. guentheri* (Peters, 1865) and *R. minimus* (Kinghorn, 1929), and gives preliminary data suggesting that *R. guentheri* is composite. Although the male genitalia of these species remain to be examined, and hence their generic identity is not confirmed (Robb 1966), they are tentatively assigned to *Ramphotyphlops* on the basis of geography (only *Ramphotyphlops* is known from Australia) and a shared supralabial imbrication pattern (McDowell 1974; Wallach 1993).

MATERIALS AND METHODS

Typhlopid holdings of all institutional collections in Australia were searched for specimens of the new species, together with material of *R. guentheri* and *R. minimus*. Individuals of the new species were found among material assigned to the latter two species. Collection abbreviations are as follows: Australian Museum - AM; Australian National Wildlife Collection - ANWC; Natural History Museum, London - BMNH; Museum of Victoria - MV; Museum and Art Gallery of the Northern Territory - NTM; Queensland Museum - QM; South Australian Museum - SAM; Western Australian Museum - WAM. Other abbreviations are: snout-vent length - SVL; body width - BW; homestead - HS.

Head scalation nomenclature follows Waite (1918). Ventral scale counts are from the postmental to the preanal scales inclusive. Subcaudal scale counts do not include the terminal thornlike scale. Whenever possible sex was determined by examination of the gonads: females on the presence of either ovaries or a right oviduct, males by the presence of testes and ductus deferens.

SYSTEMATICS

Ramphotyphlops nema sp. nov.
(Figs 1-2)

Type material. HOLOTYPE - NTM R21665, Fannie Bay, Darwin, NT. Collected 8 December 1995 by D. Low Choy. PARATYPES - AM A4872, Port Darwin, NT (no other data); MV D8408, Darwin, NT, donated C.P. Crawford; NTM R16047, Malak, Darwin, NT, R. Horner, 10 April 1990; NTM R34110, Darwin, NT, L. Brodie, December 1965; SAM R802B, northern Australia.

Diagnosis. A small, slender *Ramphotyphlops* with 16 midbody scale rows, 520 or more ventral scales, snout bluntly rounded from above and in lateral profile, and tail concolorous with body.

Description. Head in profile rounded, convexity slightly greater rostroventrally than rostrodorsally; head in dorsal view bluntly rounded, slightly squared off, lacking indentations lateral to rostral; rostral large, from above as wide as long, slightly tapered caudally, about 1/3 width of head; ventral lobe narrower, tapering caudally, lateral margins concave; nasals broadly separated by prefrontal; prefrontal and frontal subequal; supraoculars broadly separated by frontal; nostrils inferior, near apex of snout, closer to rostral than preocular, opening later-

Fig. 1. Holotype of *Ramphotyphlops nema* n. sp. in life.

ally; nasal cleft beginning at second supralabial, extending across rostroventral margin of nostril, then passing dorsally and slightly rostrally to terminate about 1/2-2/3 the distance from nostril towards rostral, not visible from above; preocular about as wide as nasal, narrower than ocular; eye small, indistinct, deep to preocular/ocular suture, and immediately ventral to preocular/ocular/supraocular junction; ocular caudally overlaps three scales of equal size, one parietal and two postoculars; first supralabial smallest, overlapped by rostral lobe of nasal; second supralabial larger, overlapped by rostral lobe and caudal lobe of nasal and preocular; third supralabial larger, overlapped by preocular, but strongly overlapping ocular; fourth supralabial much the largest, elongate, overlapped by ocular; mental subequal to postmental; infralabials three, subequal; microtubercles of head shields most dense on nasal scute; glands below margins of head shields present but not prominent.

Midbody scale rows 16; ventral scales 520-589 ($\bar{x} = 556.3$, sd = 25.0, n = 6), 544 in two females; subcaudal scales 9-14 ($\bar{x} = 10.4$, sd = 2.1, n = 5), 10 in two females.

SVL 120-268mm ($\bar{x} = 192.0$, sd = 62.2, n = 6), two of three largest individuals female; BW (%SVL) 1.08-1.75 ($\bar{x} = 1.36$, sd = 0.23, n = 6).

In alcohol, head, body and tail dorsum light yellow-brown to mid grey-brown, concolorous or with head slightly darker; venter slightly paler. In life, cranial third of dorsum pinkish brown.

Details of holotype. The holotype has SVL 268 mm, BW 3.35 mm, 589 ventral scales and nine subcaudal scales.

Comparison with other species. The combination of 16 midbody scales, 520 or more ventral scales and a bluntly rounded snout is unique among *Ramphotyphlops*. Only two described species have 16 midbody scales: *R. minimus* (Kinghorn, 1929) and *R. leptosoma* Robb, 1972. *Ramphotyphlops minimus* also shares a bluntly rounded snout with *R. nema* and is geographically close (see below). However, it differs in having a much lower ventral count (457 or fewer) and in usually having at least a dark tail, and often a dark head and striped body.

Ramphotyphlops leptosoma shares a high ventral count and concolorous body and tail with *R. nema*, but has a bluntly angular snout in profile, and a completely divided nasal scale. It is also geographically distant.

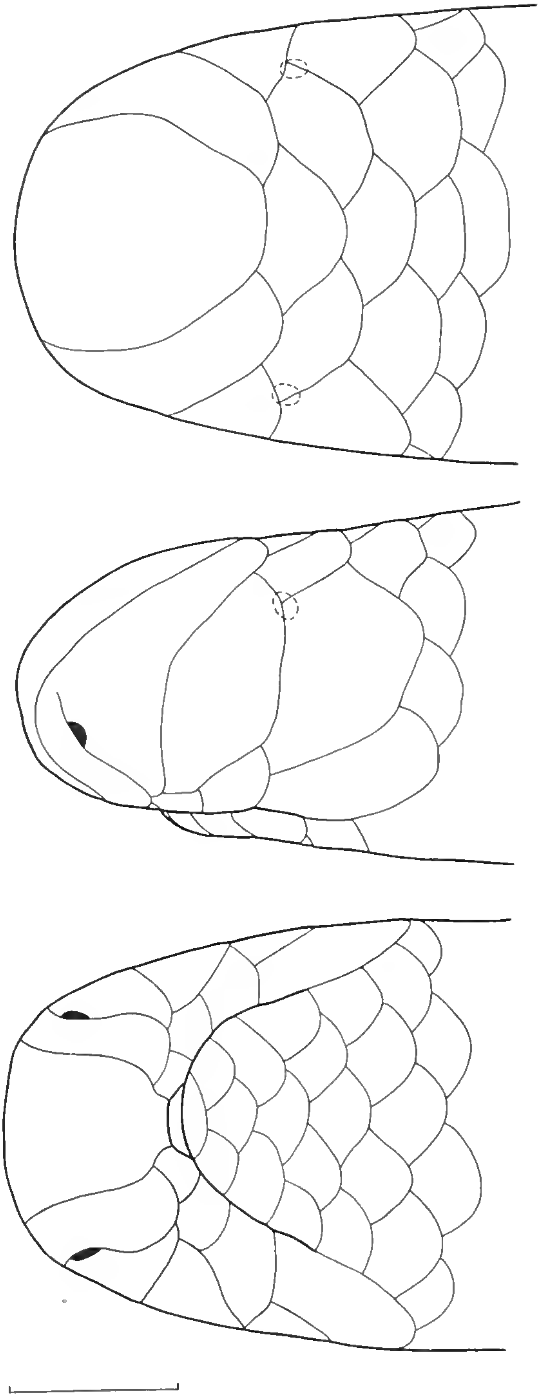

Fig. 2. Dorsal, lateral and ventral views of the head of a paratype of *Ramphotyphlops nema* n. sp. (AM A4872). Scale bar = 1mm.

Two species of *Ramphotyphlops* with 18 midbody scale rows have similarly high ventral counts to *R. nema*: *R. grypus* (Waite, 1918) and *R. guentheri* (Peters, 1865). *Ramphotyphlops grypus* differs in having a strongly hooked snout in profile, and a dark tail.

Early records of *R. nema* were incorrectly identified as *R. guentheri* (AM A4872; SAM R802B; MV D8408; at least the first two identified as such by Waite), with which it shares a rounded snout. However, the latter species differs in having a black tail, the nasal cleft scarcely extending beyond the nostril, and a characteristically truncate caudal extremity to the rostral scale.

Distribution and conservation status. All records of *R. nema* with specific localities are from the Darwin area. In addition to the type series, AM R2292, received in exchange from SAM in 1897 without further data and in poor condition, belongs to this species, while SAM R802A, previously identified as conspecific with R802B and sharing the same data, was skeletonised prior to this study, and its identity cannot now be confirmed. Of these eight specimens, four were registered prior to 1918, while one (MV D8408) was received in 1952. Despite extensive collections of reptiles from Darwin, a rapidly expanding city in recent decades, only the holotype and two NTM paratypes have been collected since 1965.

Using the quantitative ranking adopted by Cogger *et al.* (1993) to assess conservation status, and conservatively extrapolating some variables from congeners, we score *R. nema* as 35.4 (1(b); 2(b); 3(a); 4(d); 5(d); 6A(b); 6B(c); 7A(ii); 7B(b); 7C(b)). This score is within the range of scores assigned to the "Vulnerable" category.

Habitat. Habitat data are available only for the two most recently collected specimens, the holotype and paratype NTM R16047. Both were collected in heavily vegetated suburban backyards, which had in common areas of dark humic soil covered with thick leaf litter. Both specimens were located under debris embedded in the substrate, with the holotype being found under a concrete slab and the paratype under a loose pile of house bricks. *Ramphotyphlops braminus* has also been recorded at one of these sites.

Etymology. From the classical Greek *nema*, a thread, alluding to the slender body, which combines the lowest midbody counts in the genus with some of the highest ventral counts.

Ramphotyphlops minimus (Kinghorn, 1929)

This species was stated to be described from a holotype and two paratypes from Groote Eylandt (Kinghorn 1929). However, the paratypes are among three conspecific specimens then registered under one number, and it is not possible to determine whether Kinghorn erred in identifying only two paratypes, or if not, which two of the three individuals are paratypes. An additional specimen from Groote Eylandt was noted

Table 1. Comparison of variable characters between eastern and western populations of *Ramphotyphlops guentheri*.

			SVL	BW (%SVL)	Ventrals	Subcaudals
Eastern	Females	Range	119-292	1.23-2.27	464-547	8-15
		x̄	211.4	1.64	515.3	11.5
		sd	40.6	0.26	23.7	1.69
		n	21	21	21	21
	Male (n = 1)		192.5	1.90	508	17
	Pooled (females and male)	Range	118-292	1.23-2.72	464-547	8-17
		x̄	197.5	1.66	514.8	11.6
		sd	48.1	0.26	22.4	1.96
		n	26	26	25	26
Western	Females	Range	138.5-280	1.21-1.65	564-610	10-15
		x̄	227.3	1.41	584.3	12.8
		sd	52.1	0.15	15.8	1.83
		n	8	8	8	8
	Pooled (females and unsexed)	Range	132-280	1.21-1.79	564-610	10-15
		x̄	211.4	1.47	582.3	12.2
		sd	53.5	0.19	13.5	1.75
		n	12	12	12	12

by Gow (1981), but not characterised, while Wilson and Knowles (1988) provide a colour photograph of a preserved individual from Lake Evella, on the mainland. We have examined all of these specimens, together with three others.

The following description encompasses the variation in taxonomically important characters in these nine specimens: nasal cleft originating from the second supralabial, and extending beyond the nostril towards the rostral, but not completely dividing the nasal and not visible dorsally; snout rounded in lateral profile, and slightly squared off in dorsal profile; midbody scales 16; ventrals 381-457 ($\bar{x}$ = 438.0, sd = 22.1, n = 9), in three females 441-457, in two males 444-445. The only individual with ventral count below 438 is NTM R7521, which is also unique in coloration (see below). Subcaudals 9-17 ($\bar{x}$ = 11.6, sd = 2.51, n = 9), in three females 9-11, in two males 12-14.

The SVL is 109-215mm ($\bar{x}$ = 166.9 mm, sd = 36.0 mm, n = 9), in three females 109-189 mm,

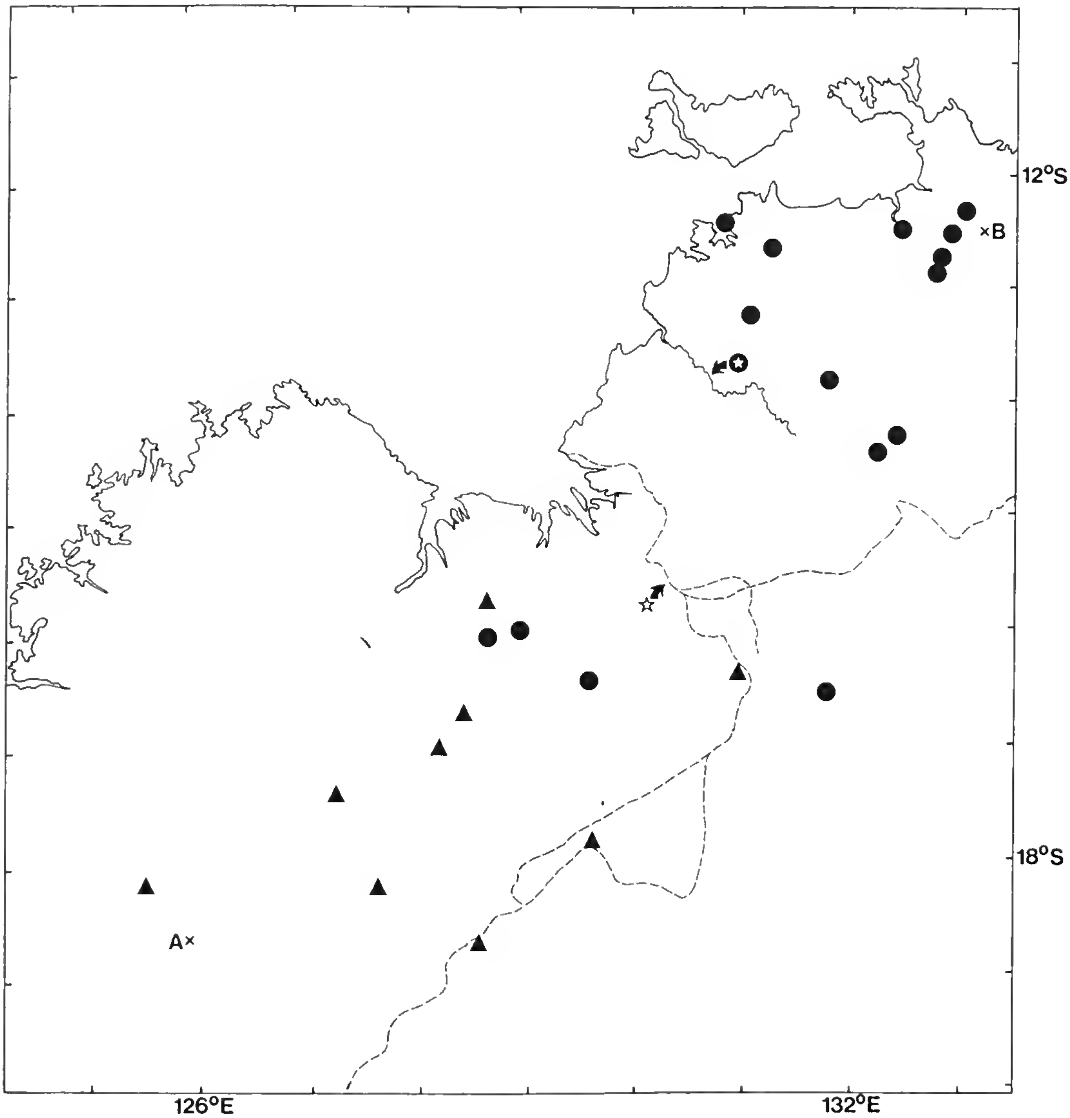

Fig. 3. Distribution of *Ramphotyphlops guentheri*. Dots indicate the eastern form; triangles, the western form; starred dot indicates the Daly River, type locality for *Typhlops nigricauda*; star indicates most likely locality for type of *Typhlops guentheri*. Dashed line indicates approximate routes followed by Gregory's Northern Australian Expedition of 1855-56. Crosses A and B indicate transect plotted in Figure 4.

in two males 177.5-202 mm; BW (%SVL): 1.42-1.94 ($\bar{x}$ = 1.63, sd = 0.19, n = 9), in three females 1.43-1.85, in two males 1.53-1.94.

The head and tail are much darker than body, and body usually with narrow dark stripes, at least ventrally. The exception is NTM R7521 (SVL 176 mm) which lacks stripes and has the head and tail concolorous with the body.

Geographic variation. The single mainland specimen, an adult male, from a locality approximately 170 km NNW of Groote Eylandt, falls within the range of variation of Groote Eylandt material.

Specimens examined. AM R9692 (holotype), R9693, R61025-26 (paratypes), Groote Eylandt, NT; AM R10367, northern Australia; AM R40918, Lake Evella, NT; AM R71301, Angurugu Mission, Groote Eylandt, NT; NTM R7521, Mayada, Groote Eylandt, NT; NTM R9874, Angurugu, Groote Eylandt, NT.

Ramphotyphlops guentheri (Peters, 1865)

This species was described from a single specimen from "Nordaustralien" in the British Museum. The holotype (BMNH 1946.1.10.88) was collected by the North Australian expedition of 1855-56 led by A.C. Gregory, with naturalist J.R. Elsey. Although no more specific locality is available, it is likely that it was collected from the major campsite of the expedition on the Victoria River, NT, where Elsey, together with most of the party, stayed from October 1855 to June 1856 while Gregory explored to the southwest (Gregory and Gregory 1884). After this date, the expedition travelled rapidly east, beyond the known range of the species.

Boulenger (1895) described *Typhlops nigricauda* from two specimens from the Daly River, but did not compare it with *R. guentheri*. The two species were synonymised by Waite (1918) without examination of type material.

Examination of all available material of *R. guentheri* in Australian collections reveals that ventral scale counts are discontinuous. Eastern material, from Wyndham to Oenpelli, has low numbers of ventral scales (547 or fewer), while western material, from Fitzroy Crossing to "Victoria River Downs" HS, has high numbers of ventral scales (564 or more; Table 1). There is geographic overlap between these two groups in the east Kimberley and adjacent parts of the Northern Territory (Figs 3-4), although syntopy is not yet recorded. The holotype of *Typhlops guentheri*, with ventral scale count of 568, belongs to the western group, while one of the two syntypes of *Typhlops nigricauda* (BMNH 1946.1.11.13, here designated lectotype) is assignable to the eastern group on locality (Fig. 3) and ventral scale count (530).

No other obvious variation between or within these two groups was apparent (Table 1). In the absence of concordant variation in independent characters, genetic data or evidence of repro-

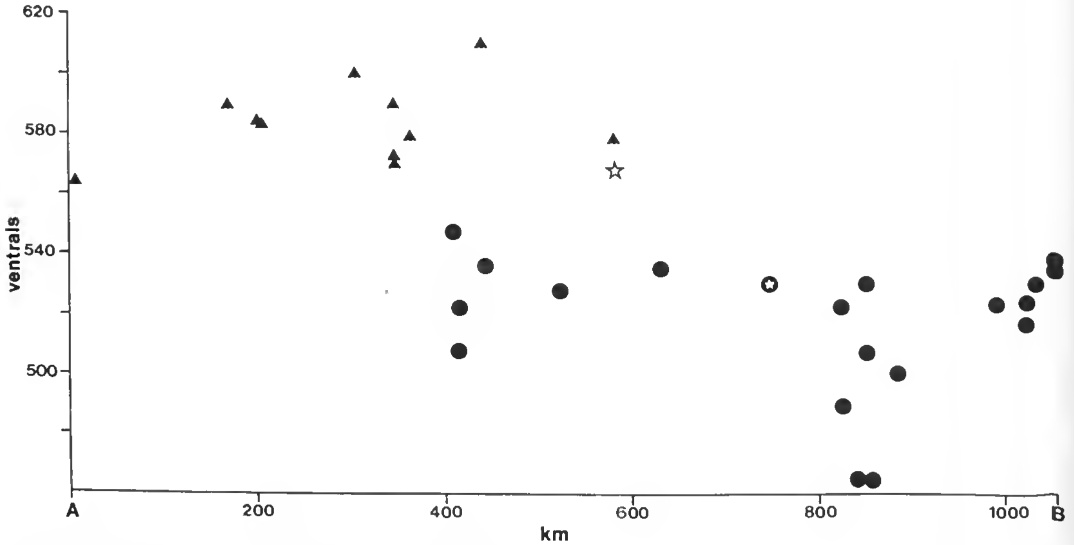

Fig. 4. Geographic variation in number of ventral scales in *Ramphotyphlops guentheri*. X axis is km from point A to point B on Figure 3. Symbols as in Figure 3.

ductive isolation by the occurrence of syntopy, we are reluctant to formally recognise these two groups as distinct species. Much additional material, preferably with accompanying genetic studies (Aplin and Donnellan 1993), is required to resolve the status of these two groups.

An additional peculiarity in *R. guentheri* is the preponderance of females in the available samples. Of 22 sexed individuals of the eastern group, 21 are females, based on the presence of either ovaries and/or an oviduct, while only one (WAM R61353) is a male. All eight individuals of the western group which were sexable by internal examination are female, and the remainder had similarly proportioned tails and similar subcaudal counts. These sex ratios are highly significantly different from equality (eastern: $c^2 = 16.4$, $p<0.001$; western: $c^2 = 6.1$, $p<0.05$). Whether this highly skewed sex ratio is real or an artefact of collection is at present unknown. If real, its biological significance will require much additional ecological and genetic data. However, it is worthy of note that at least one other typhlopid, *Ramphotyphlops braminus* (Daudin, 1803) is a triploid parthenogen (Wynn *et al.* 1987; Ota *et al.* 1991), yet uncomfirmed reports of occasional males exist (see Nussbaum 1980 for discussion).

Specimens examined. *Eastern form.* ANWC R3604, Jabiru area, NT; ANWC R5120, Noranda Camp, Nourlangie Rock area, NT; BMNH 1946.1.11.13, Daly River, NT (lectotype of *Typhlops nigricauda*); MV R7073, NTM R915-16, Oenpelli, NT; MV D8801, NT; MV D11002, Dingo Gap, on WA border between Wyndham and Timber Creek, NT; MV R7111, NTM R9849, no data; NTM R2568, The Pines, Pine Creek, NT; NTM R4202, Adelaide River, NT; NTM R5180, Kapalga study area, NT; NTM R6932, Katherine, low level, NT; NTM R8690, Rock Hole, 68km E Pine Creek, NT; NTM R13553, R13611, Katherine Gorge camping area, NT; NTM R16488, Top Springs, NT; NTM R16907, Kakadu stage 3, NT; NTM R34103, Beatrice Hill, NT; QM J2266, Port Darwin, NT; WAM R21935, Katherine, NT; WAM R24006, Snake Creek, 12km N Adelaide River, NT; WAM R31520, Wyndham, WA; WAM R40997, "Kildurk", NT; WAM R61352, Lake Argyle, main dam site, WA; WAM R61353, "Argyle Downs" HS, WA.

Western form. BMNH 1946.1.10.88, north Australia (holotype of *Typhlops guentheri*); MV D4715, Turkey Creek, WA; NTM R284, "Gordon Downs", WA; NTM R2227, "Victoria River Downs" HS, NT; NTM R6741, 5 km W Ivanhoe Crossing, WA; SAM R14026, "Inverway" Stn, NT; WAM R26635, near Halls Creek, WA; WAM R28234, Fitzroy Crossing, WA; WAM R32283, Elgee Cliffs, WA; WAM R70322, 12 km WSW (new) "Lissadell" HS, WA; WAM R70361, 13 km NW (new) "Lissadell" HS, WA; WAM R70836, 12.5 km 309° (new) "Lissadell" HS, WA.

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CHILOTHYNNUS, A NEW GENUS OF AUSTRALIAN THYNNINAE (HYMENOPTERA: TIPHIIDAE) ASSOCIATED WITH ORCHIDS.

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ABSTRACT

Chilothynnus gen. nov. is erected for six new species: *C. palachilus* sp. nov. (type-species), *C. boweri* sp. nov. , *C. macraei* sp. nov. , *C. rossi* sp. nov. , *C. sandaracus* sp. nov. and *C. trochanterinus* sp. nov. All are described from the male. The males of at least *C. palachilus*, *C. sandaracus* and *C. trochanterinus* are attracted to orchids belonging to the genus *Chiloglottis*.

KEYWORDS: Tiphiidae, Thynninae, *Chiloglottis*, *Chilothynnus*, Australia, new genus, new species.

INTRODUCTION

The literature published on the pollination of Australian orchids by thynnine (Tiphiidae: Thynninae) wasps has been reviewed by Armstrong (1979) and Adams and Lawson (1993). No work on the taxonomy of orchid-pollinating thynnine wasps has been published previously.

Chilothynnus is a distinctive genus of small wasps. Six new species are included. All are similar in appearance, and are most reliably distinguished by examining the male genitalia. At least three of these species can be attracted to the orchid flowers of *Chiloglottis* R. Brown (Orchidaceae: Drakaeinae) using baiting techniques as described by Bower (1996).

Terminology follows Snodgrass (1941), Brown (1989) and Naumann (1991). Microsculpture is interpreted as follows: sparsely punctate = punctures further than two puncture-diameters apart; punctate = punctures at most two puncture-diameters apart but not confluent; closely punctate = punctures almost confluent; rugosely punctate = punctures partially confluent; finely punctate= small and shallow; and coarsely punctate = large and deep.

Abbreviations. Morphological characters: T1-7, metasomal tergites 1-7; S1-8, metasomal sternites 1-8. Specimen repositories: AM, Australian Museum, Sydney; ANIC, Australian National Insect Collection, CSIRO, Canberra; BCRI, Biological and Chemical Research Institute, NSW Agriculture, Rydalmere; BMNH, The Natural History Museum, London; NTM, Museum and Art Gallery of the Northern Territory, Darwin. Collectors: CCB, C.C. Bower.

SYSTEMATICS

Chilothynnus gen. nov.

Type-species. *Chilothynnus palachilus* sp. nov.

Diagnosis of male. Small (body length 4-10 mm) black wasps usually with yellow markings on the head and mesosoma, often with lateral spots on T2-4, often with legs at least partially orange, rarely with metasoma ferruginous. Clypeus narrowly raised medially, sagittally carinate and narrowly truncate. Antennal prominence broadly U-shaped, sagittally carinate. Apical 5 antennal segments arcuate. Propodeum longer than wide, gently curved in profile without clearly defined posterior declivity. Metasoma dorsoventrally compressed, not strongly sclerotised; segment 2 constricted anteriorly; segment 3 at most weakly constricted anteriorly; other segments not constricted. T1 longer than wide. S1 not strongly raised medially. Epipygium (T7) convex, strongly and coarsely punctate laterally, broadly impunctate medially. Hypopygium acutely spinose laterally, rounded, truncate or pointed but not spinose apically. Genitalia with basal ring short and ring-like; aedeagus reaching to, or extending beyond level of paramere apices; parameres usually notched or lobed on ventral margin.

Diagnosis of female. Small, apterous, brown wasps. Pronotum almost flat without tubercles, depressions or sulci; T2 with basal, weak apical and two strongly raised transverse carinae on disc; S5 punctate.

Etymology. The generic name is masculine and derived from *Chiloglottis*, a genus of orchid pollinated by *C. palachilus* sp. nov., *C. sandaracus* sp. nov. and *C. trochanterinus* sp. nov.

KEY TO MALES OF *CHILOTHYNNUS*

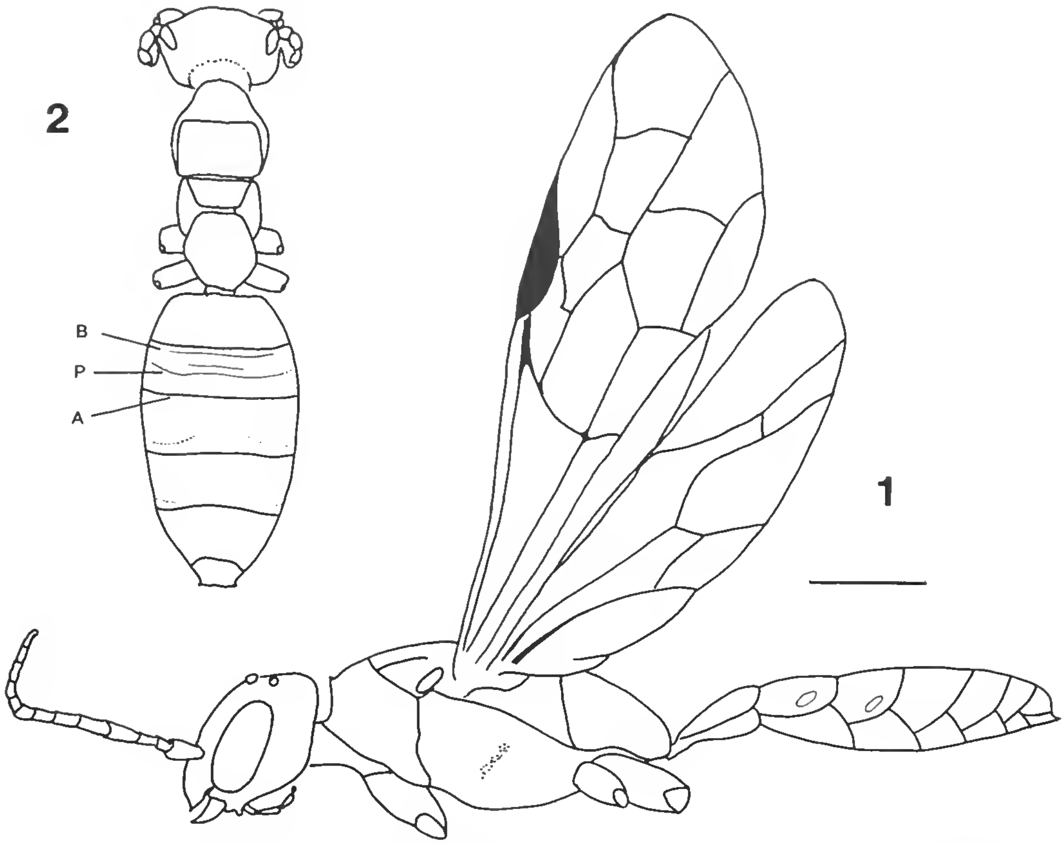
(Only the female of *C. trochanterinus* is known)

1\. a Hypopygium narrowly rounded, truncate or triangular apically (Figs 7-8) 2
   b Hypopygium broadly rounded apically (Figs 3-6) 3
2\. a All metasomal segments black (with or without pale oblique marks).................. .... *C. boweri* sp. nov.
   b Basal three metasomal segments orange .... *C. sandaracus* sp. nov.
3\. a Mid and hind trochanters spinose ventro-apically.......... *C. trochanterinus* sp. nov.
   b Trochanters not spinose 4
4\. a Body length ≥7 mm; ventral margin of paramere lobed in profile (Fig. 10) .... *C. palachilus* sp. nov.
   b Body length ≤7 mm; ventral margin of paramere not lobed in profile 5
5\. a Body length 5-7 mm; aedeagus swollen; parameres short and subtriangular (Fig. 13).......................... *C. macraei* sp. nov.
   b Body length 4-4.5 mm; aedeagus narrow and subparallel; parameres long and subtriangular (Fig. 12)....... *C. rossi* sp. nov.

Chilothynnus palachilus sp. nov.
(Figs 1, 6, 10)

Type material. HOLOTYPE male - NTM (I593): Mt Kaputar, New South Wales, (site 3), attracted to *Chiloglottis palachila* ex Mt Kaputar, 7 November 1993, CCB. PARATYPES - NEW SOUTH WALES: AM, BMNH, NTM (39 males), same data as holotype; AM, ANIC, BMNH, NTM (10 males); Mt Kaputar, (site 1), attracted to *Chiloglottis palachila* ex Mt Kaputar, 7 November 1993, CCB; AM, ANIC, NTM (5 males), Mt Kaputar, (site 3), attracted to *Chiloglottis chlorantha* ex Kanangra-Boyd NP, 7 November 1993, CCB; AM, ANIC, NTM (2 males), Mt Kaputar, (site 3), attracted to *Chiloglottis* aff. *palachila* ex Sunny Corner, 7 November 1993, CCB; AM, ANIC, NTM (6 males), Banksia Pt, New England NP, attracted to *Chiloglottis palachila* ex Barrington Tops, 2 December 1993, CCB; NTM (1 male), Banksia Pt, New England NP, attracted to *Chiloglottis pluricallata* ex Barrington Tops, 2 December 1993, CCB; NTM (3 males), Cathedral Rocks NP, attracted to *Chiloglottis palachila* ex Barrington Tops, 1 December 1993, CCB; AM, ANIC, BMNH, NTM (12 males), Yarrangobilly Caves Rd, Kosciusko NP, attracted to *Chiloglottis palachila* ex Barrington Tops, 8 December 1993, CCB; NTM (1 male), Mt Carson, 2 km E of Polblue Swamp, attracted to *Chiloglottis palachila* ex Mt Carson, Barrington Tops, 2 January 1994, CCB; AM, NTM (15 males), 0.5 km S of Big Murray Swamp, Barrington Tops, attracted to *Chiloglottis palachila* ex Mt Carson, Barrington Tops, 2 January 1994, CCB; NTM (3 males), New England NP. nr Platypus V[alley] L[ook]O[ut], attracted to *Chiloglottis palachila* ex Mt Carson, Barrington Tops, 31 December 1993, CCB; AM (1 male), Royal National Park, 28 November 1964, D.K. McAlpine; AM (1 male), Mt Banda Banda, 1200 m, 8 December 1986, D. Bickel; AM (2 males), Mt Tomah, December 1985, N. Rodd; AM (1 male), Mt Wilson, 29 November 1984, D.K. McAlpine and B. Day.

Other material. NEW SOUTH WALES: NTM (2 males), Barrington Tops, attracted to *Chiloglottis palachila* ex Barrington Tops, 9-10 January 1993, CCB; NTM (1 male), Banksia Pt, New England NP, attracted to *Chiloglottis palachila* ex Barrington Tops, 2 December 1993, CCB; NTM (1 male), Banksia Pt, New England NP, attracted to *Chiloglottis* aff. *palachila* ex Sunny Corner, 2 December 1993, CCB; NTM (1 male), Cockerill's Lookout, Kanangra-Boyd NP, attracted to *Chiloglottis palachila* ex Barrington Tops, 21 November 1993, CCB; NTM (15 males), Banksia Pt, New England NP, attracted to *Chiloglottis* aff. *palachila* ex Sunny Corner, 2 December 1993, CCB; ANIC (5 males), Kiandra, 20 December 1960, E.F. Riek.



Figs 1-2. 1, *Chilothynnus palachila* sp. nov., male, lateral. **2**, *C. trochanterina* sp. nov., female, dorsal. A, apical carina of T2; B, basal carina of T2; P, preapical carina of T2. Scale line = 1 mm.

Description of male. Body length 7-10 mm; fore wing 5-9 mm; hind wing 4-7 mm. Clypeus closely and finely punctate. Frons closely punctate to rugosely punctate. Vertex and gena closely punctate. Pronotum finely and shallowly punctate. Mesoscutellum and mesoscutum closely punctate. Metanotum sparsely punctate. Propodeum closely punctate becoming transversely striate posteriorly. Mesopleuron closely punctate. Fore coxae with anteroventral surface slightly concave. Trochanters not spinose. Tergites closely and finely punctate. S1 closely and finely punctate. S2-4 almost impunctate. S5-8 punctate. Hypopygium broadly rounded apically. Genitalia as in Figure 10. Parameres elongate triangular with rounded ventral lobe.

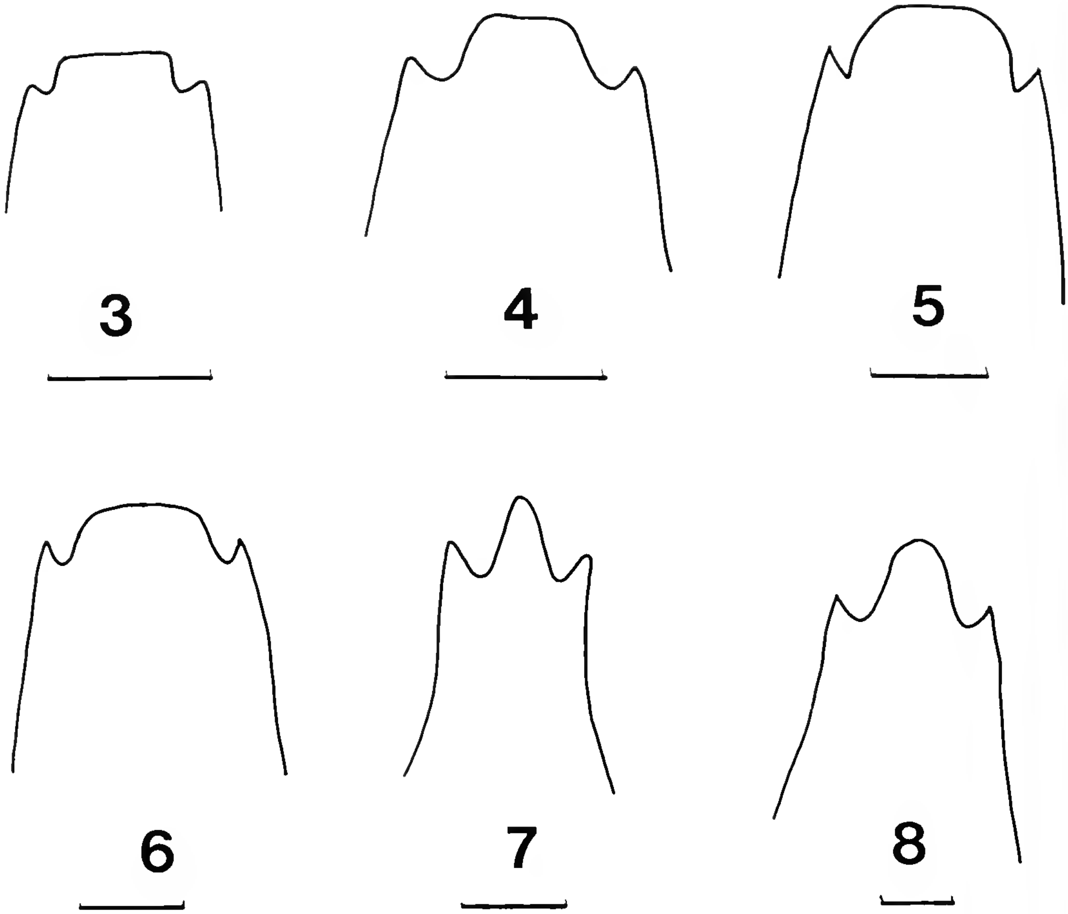
Colour. Black; inner orbits ventrally and narrowly, anterior margin of pronotum narrowly, metanotum, lateral spots on T2-4 (largest on T2, smallest or absent on T4) pale yellow; legs orange; mandibles, ventral surface of basal 8 antennal segments, and small postocellar spot brown. Setae white. Wings hyaline, veins dark brown to black.

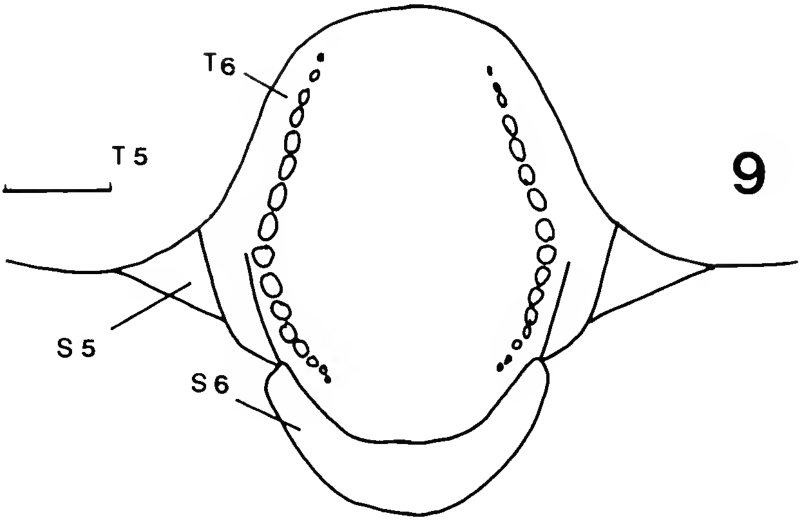
Distribution. Ranges of northern, central and southern New South Wales.

Remarks. Pale yellow marks on inner orbits, pronotum, metanotum, and T3-4 may be reduced or absent. Brown colouration on antennae may be absent.

This species pollinates *C. palachila* within the normal range of the orchid. However, some specimens were attracted to flowers of *C. chlorantha* D.L. Jones which had been translocated from Kanangra-Boyd NP, and *C.* aff. *palachila* which had been translocated from Sunny Corner. However, these wasps did not exhibit appropriate behaviour for pollination to occur (C.C. Bower pers. comm.).

Non type specimens (except those from Barrington Tops which were too damaged to be nominated as types) have the legs black rather than orange. In comparative experiments (C.C. Bower, pers. comm.) most of the New England





Figs 3-9. **3-8**, apex of male hypopygia (S8): **3**, *Chilothynnus rossi* sp. nov.; **4**, *C. macraei* sp. nov.; **5**, *C. trochanterinus* sp. nov.; **6**, *C. palachilus* sp. nov.; **7**, *C. boweri* sp. nov.; and **8**, *C. sandaracus* sp. nov. **9**, *C. trochanterinus* sp. nov., female, pygidium and apex of metasoma. Scale lines = 0.1 mm.

National Park specimens were preferentially attracted to *C.* aff. *palachila* rather than to *C. palachila*. No obvious differences between the genitalia of these two groups are evident. On the basis of these comparative observations, I am reluctant to consider them to be conspecific as structural differences in male genitalia are sometimes slight in closely related species. The Kiandra specimens have the apex of the hypopygium slightly more produced and almost broadly triangular.

Etymology. The species is named after the orchid it pollinates, *Chiloglottis palachila* D.L. Jones.

Chilothynnus boweri sp. nov.
(Figs 7, 11)

Type material. HOLOTYPE male - NTM (I594): Travelling Stock Reserve (Olympic Way), Bendick Murrell, N of Young, New South Wales, 24 March 1988, CCB. PARATYPES - NEW SOUTH WALES: NTM (2 males), data as holotype; NTM (1 male), Mullion Ck, 14 March 1993, CCB; BCRI, NTM (3 males), "Daisy Hill", 152°10'E, 30°29'S, 11.5 km ENE of Wollomombi, ex Malaise trap, 28 November 1991 (trap 3), 4 February 1993 (trap 7) or 27 January 1994 (trap 6), A. Campbell and C. Haywood.

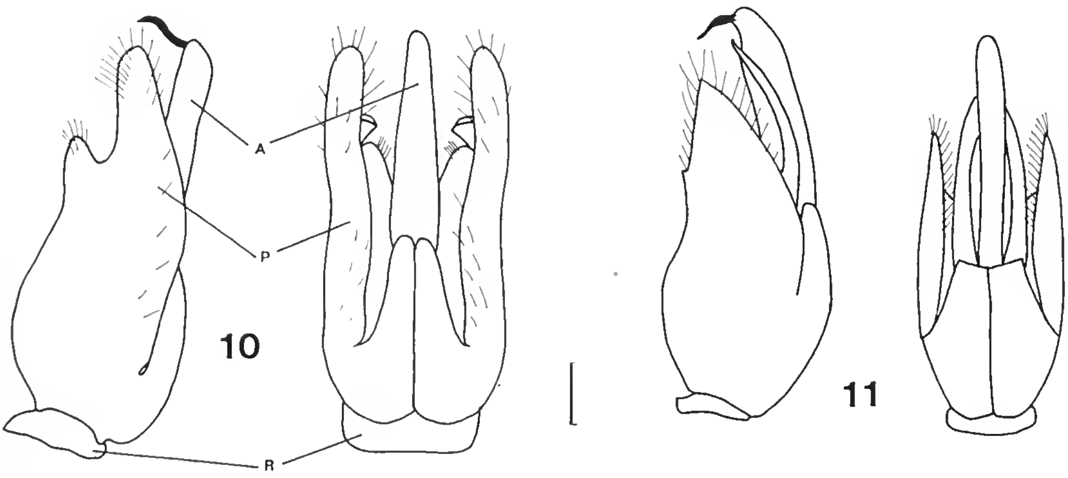
Description of male. Body length 4.5-5.5 mm; fore wing 3.5-4 mm; hind wing 2.5-3 mm. Clypeus closely and finely punctate. Frons closely punctate. Vertex and gena punctate to closely punctate. Pronotum finely and shallowly punctate. Mesoscutum closely and finely punctate. Mesoscutellum punctate. Metanotum sparsely punctate. Propodeum closely punctate. Mesopleuron closely punctate. Fore coxae with anteroventral surface broadly and shallowly concave, not tuberculate. Trochanters not spinose. T1-2 impunctate, T3-5 reticulate and finely punctate, T6-7 coarsely punctate. S1 closely and finely punctate. S2-8 reticulate, almost impunctate. Hypopygium triangular apically. Genitalia as in Figure 11. Parameres subtriangular with minute ventral tooth.

Colour. Black; mandible (except apex), margins of clypeus narrowly, inner and outer orbits ventrally and narrowly, margin of antennal prominence narrowly, pronotum with margins narrowly and small ventral spot, metanotum, tegula anteriorly, small dorsal spot on mesopleuron, lateral oblique mark on T2-4, small posterolateral spot on S2-4 pale yellow; legs orange to brown; small postocellar spot brown. Setae white. Wings hyaline, veins dark brown.

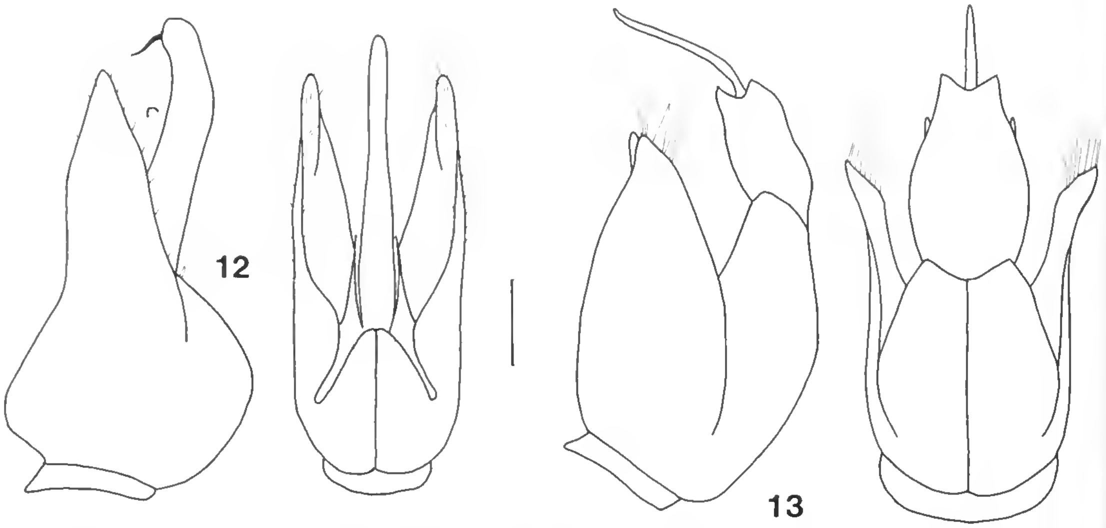
Distribution. Northern and southern Tablelands of New South Wales.

Remarks. Pale yellow marks may be reduced to absent on outer orbit, mesopleuron, T4 and S4.

Etymology. The species is named after Dr Col. Bower who has contributed greatly to our knowledge of orchid pollination and orchid pollinators.



Figs 10-11. *Chilothynnus* spp., male genitalia, lateral and dorsal: 10, *C. palachilus* sp. nov.; 11, *C. boweri* sp. nov. A, aedeagus; P, paramere; R, basal ring. Scale line = 0.1 mm.



Figs 12-13. *Chilothynnus* spp., male genitalia, lateral and dorsal: **12**, *C. rossi* sp. nov.; **13**, *C. macraei* sp. nov. Scale line = 0.1 mm.

Chilothynnus macraei sp. nov.
(Figs 4, 13)

Type material. HOLOTYPE male - BCRI: "Fairburn", 152°10'E, 30°27'S, 11.5 km ENE of Wollomombi, New South Wales, ex Malaise trap, 15 October 1992 (trap 21), A. Campbell and C. Haywood. PARATYPES - NEW SOUTH WALES: BCRI, NTM (10 males), "Daisy Hill", 152°10'E, 30°29'S, 11.5 km ENE of Wollomombi, ex Malaise trap, 8 September 1991 (trap 1), 18 October 1991 (2, trap 1), 25 October 1991 (5, trap 1), 1 November 1991 (trap 5) 15 November 1991 (trap 1), A. Campbell and C. Haywood; QUEENSLAND: ANIC (1 male), Tewah Ck via Tin Can Bay, 17-18 October 1970, S.R. Monteith.

Description of male. Body length 5-7 mm; fore wing 4-5 mm; hind wing 3-4 mm. Clypeus closely and finely punctate. Frons closely punctate to rugosely punctate. Vertex rugosely punctate. Gena closely punctate. Pronotum punctate becoming rugose ventrally. Mesoscutum and mesoscutellum closely punctate to rugosely punctate. Metanotum sparsely punctate. Propodeum closely punctate becoming transversely striate posteriorly. Mesopleuron closely punctate to rugosely punctate. Fore coxae slightly convex, not tuberculate. Trochanters not spinose. Tergites reticulate and finely punctate, T6-7 coarsely punctate. Sternites almost impunctate. Hypopygium truncate apically. Genitalia as in Figure 13. Parameres subtriangular without ventral lobes or teeth.

Colour. Black; inner orbits of eyes ventrally and narrowly, margin of clypeus (except medially), margin of antennal prominence narrowly, margins of pronotum narrowly, and small dorsal spot on mesopleuron yellow; oblique lateral marks on T2-3 (often obscure or absent) pale yellow; apical margin of clypeus medially, legs (except coxae) and metasoma (except T1 and S1, and often T4 and T5) reddish orange; postocellar spot usually extending from outer orbit of eye to base of mandible brown. Setae white. Wings hyaline, veins light brown.

Distribution. South-eastern Queensland and northern Tablelands of New South Wales.

Remarks. The colour of this species is more variable than other species: yellow colouration may be limited to the antennal prominence while the legs and metasoma may be much darker, or black. Typically, specimens retain the yellow colouration on the head and pronotum, reddish-orange legs and some indication of reddish-orange on some metasomal segments.

Orchids of the genus *Chiloglottis* do not occur on or adjacent to the properties "Fairburn" and "Daisy Hill" (Mackay, Campbell, and Brown, unpublished). Three species of *Chiloglottis* (*C. anaticeps* D.L. Jones, *C. pluricallata* and *C. trilabra* Fitz.) do however, occur at nearby Cathedral Rocks National Park, but none of these are known to be visited or pollinated by *Chilothynnus* species (C.C. Bower, pers. comm.).

Etymology. The species is named after Allan McRae, the owner of "Fairburn".

Chilothynnus rossi sp. nov.
(Figs 3, 12)

Type material. HOLOTYPE male - BCRI: "Daisy Hill", 152°10'E, 30°29'S, 11.5 km ENE of Wollomombi, New South Wales, ex Malaise trap, 26 December 1991 (trap 1), A. Campbell and C. Haywood. PARATYPES - NEW SOUTH WALES: BCRI, NTM (6 males), as holotype (2) or dated 30 January 1992 (3, trap 7) or 21 January 1993 (1, trap 7).

Description of male. Body length 4-5 mm; fore wing 4-4.5 mm; hind wing 3-3.5 mm. Clypeus closely and finely punctate. Frons rugosely punctate. Vertex and gena closely and finely punctate. Pronotum closely punctate. Mesoscutum and mesoscutellum closely punctate. Metanotum sparsely punctate. Propodeum closely punctate becoming transversely striate posteriorly. Mesopleuron closely to rugosely punctate. Fore coxae convex. Trochanters not spinose. Tergites reticulate and finely punctate, coarser on T6-7. Sternites almost impunctate. Hypopygium broadly rounded apically. Genitalia as in Figure 12. Parameres elongate triangular without ventral lobes or teeth.

Colour. Black; mandibles (except apex), margin of antennal prominence narrowly, posterior margin of pronotum narrowly, metanotum and small dorsal spot on mesopleuron (often absent) yellow; oblique lateral mark on T2-3 (may be indistinct or absent) pale yellow; tibiae and tarsi orange to brown; small postocellar spot brown. Setae white. Wings hyaline, veins pale brown.

Distribution. Northern Tablelands of New South Wales

Remarks. Although not labelled as such, all specimens from "Daisy Hill" and "Fairburn" (including the other species described here) are ex ethanol, and the yellow colouration may have faded in these specimens.

Etymology. The species is named after Malcolm Ross, the owner of "Daisy Hill".

Chilothynnus sandaracus sp. nov.
(Figs 8, 14)

Type material. HOLOTYPE male - NTM (I595): Banksia Pt, New England NP, New South Wales, attracted to *Chiloglottis valida* ex Mt Canobolas, 2 December 1993, CCB. PARATYPES - NEW SOUTH WALES: AM (1 male), Cheltenham, 9 September 1950; AM (1 male), Kurrajong, 26 October 1966, D.K. McAlpine and G.A. Holloway; AM (1 male), Lane Cove, 23 March 1946; AM (1 male), Mt Wilson, 16 December 1981, G.A. Holloway.

Description of male. Body length 9-10 mm; fore wing 7-8 mm; hind wing 4-5 mm. Clypeus closely and finely punctate. Frons coarsely rugosely punctate. Vertex and gena finely rugosely punctate. Pronotum closely punctate becoming finely punctate medially and rugosely punctate laterally. Mesoscutum and mesoscutellum closely to rugosely punctate. Metanotum sparsely punctate. Propodeum closely punctate becoming transversely striate posteriorly. Mesopleuron closely punctate. Fore coxae broadly and strongly concave with small erect apical tubercle. Trochanters not spinose. Tergites finely punctate, sparser on anterior segments, coarser on posterior segments. Sternites sparsely punctate, closely punctate posteriorly on S4-6. Hypopygium narrowly rounded apically. Genitalia as in Figure 14. Parameres triangular with apically setose ventroapical digitate lobe.

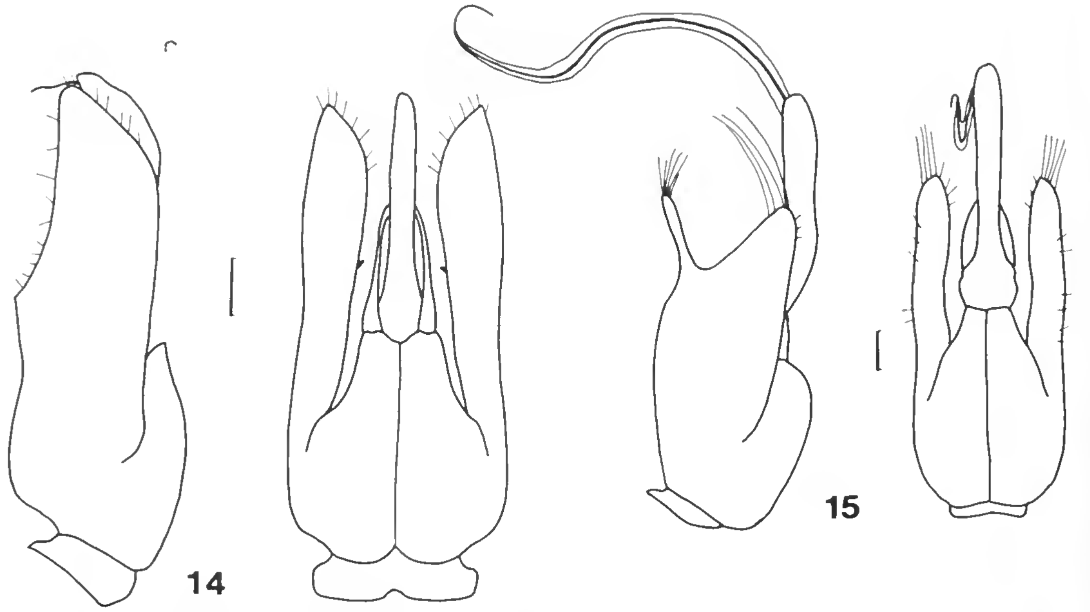
Colour. Black; mandible (except apex), margins of clypeus, inner orbits ventrally, margin of antennal prominence narrowly, anterior margin of pronotum narrowly, metanotum, and tegula yellow; transverse postocellar-postocular mark, legs (except coxae) and metasomal segments 1-3 orange. Setae pale yellow. Wings lightly infused with yellow, veins orange or dark brown.

Distribution. Coast and ranges of New South Wales.

Remarks. Black areas on the clypeus, basal eight antennal segments, lower frons, posterior margin of pronotum, discs of mesoscutellum and mesoscutum, metanotum laterally, propodeum and base of S1 may be orange.

This species was attracted to *Chiloglottis valida* D.L. Jones which had been translocated from Mt Canobolas, near Orange, to Banksia Point, New England National Park. *Chilothynnus palachilus* also occurs at Banksia Point and occurs at the same time of year as *C. sandaracus*. It is considered by C.C. Bower (pers. comm.) to be a minor responder to *C. valida* and is not regarded as a potential pollinator of this species.

Etymology. The specific name is derived from the Latin and refers to the colour of the basal metasomal segments.



Figs 14-15. *Chilothynnus* spp., male genitalia, lateral and dorsal: **14**, *C. trochanterinus* sp. nov.; **15**, *C. sandaracus* sp. nov. Scale lines = 0.1 mm.

Chilothynnus trochanterinus sp. nov.
(Figs 2, 5, 9, 15)

Type material. HOLOTYPE male - NTM (I596): "Kooroo", Calula Ra., Mullion Ck, New South Wales, attracted to *Chiloglottis* aff. *palachila* ex Sunny Corner, 9 November 1993, CCB. PARATYPES - NEW SOUTH WALES: AM, ANIC, BMNH, NTM (22 males), "Kooroo", Calula Ra., Mullion Ck, N.S.W., attracted to *Chiloglottis* aff. *palachila* ex Sunny Corner, 9 November 1993, 17 November 1993, CCB; AM, ANIC, BMNH, NTM (29 males, 2 females), "Kooroo", Calula Ra., Mullion Ck, N.S.W., attracted to *Chiloglottis chlorantha*, ex Kanangra-Boyd NP, 6 November 1993, CCB; NTM (1 male), Mullion Ck, attracted to *Chiloglottis* aff. *formicifera* ex Bald Rock [NP], 7 October 1994, CCB; VICTORIA: ANIC (1 male), 37°07'S, 142°24'E, 11 km WNW Halls Gap, 21 October 1983, I.D. Naumann and J.C. Cardale.

Description of male. Body length 9-10 mm; fore wing 7-9 mm; hind wing 5-6 mm. Clypeus closely and finely punctate. Frons, vertex and gena closely punctate to rugosely punctate. Pronotum finely and shallowly punctate. Mesoscutum closely punctate to rugosely punctate. Mesoscutellum closely punctate. Metanotum sparsely punctate. Propodeum closely punctate, transversely striate. Mesopleuron closely punctate. Fore coxae with anteroventral surface with strongly concave depression. Mid and hind trochanters spinose ventroapically. Tergites reticulate and very finely punctate, T6-7 coarsely punctate. Sternites sparsely punctate, punctures becoming closer posteriorly and anteriorly on posterior segments. Hypopygium broadly rounded apically. Genitalia as in Figure 15. Parameres subparallel with small ventral lobe.

Colour. Black; mandibles (except apex), margin of clypeus narrowly, margin of antennal prominence narrowly, anterior margin of pronotum narrowly, minute spot anterior to tegula and mesoscutum anterior to tegula, metasoma, margins of mesosternal lamellae, lateral oblique mark on T2-4 (smaller on T4) and small posterolateral spot on S2-3 pale yellow; tibiae (except outer surface) and femora orange; fore trochanters variably orange to dark brown; small postocellar spot, outer surface of tibiae, and tarsi brown. Setae white. Wings hyaline, veins dark brown to black.

Description of female. Body length 5 mm. Head subrectangular, without depressions, slightly wider than long, posterior angles strongly rounded. Clypeus narrowly truncate, medially raised. Frons deeply and sparsely punctate, medially raised above antennae. Vertex deeply and sparsely punctate. Pronotum wider than long, closely punctate. Propodeum obliquely truncate posteriorly, truncation closely and finely punctate, slightly longer than length of dorsal surface which is deeply and sparsely punctate, lateral surface and mesopleura reticulate. T1 vertically truncate anteriorly, dorsal surface testaceous with indistinct apical carina, preapical carina represented by curved line of punctures. T2 testaceous. T3-5 reticulate and closely punctate, testaceous posteriorly. Pygidium (T6) subovate with two rows of strongly developed punctures which diverge medially (Fig. 9).

Colour. Brown, antennae and legs paler, head and mesosoma darker.

Distribution. Ranges of Victoria and central Tablelands of New South Wales.

Remarks. In the male, the yellow marks on clypeus, mesoscutum, tegula and S3 may be reduced or absent.

Although strongly attracted to *C.* aff. *palachila* and *C. chlorantha*, this species occurs outside the range of, and in different habitats to, these orchids (C.C. Bower, pers. comm.) and the wasp is therefore not a natural potential pollinator of either species.

Etymology. The specific name refers to the distinctive mid and hind trochanters of this species.

DISCUSSION

Chilothynnus belongs to the group which includes *Aeolothynnus* Ashmead, *Agriomyia* Guérin, *Ariphron* Erichson, *Leiothynnus* Turner, *Neozeleboria* Rohwer, *Pentazeleboria* Brown, *Phymatothynnus* Turner, *Psammothynnus* Ashmead, *Tachynomyia* Guérin, *Tachyphron* Brown, and *Zeleboria* Saussure. This group of 12 genera is distinguished from other Australian Thynninae by the combination of: a relatively short, weakly protruding hypopygium that is not broadened into lobes or spines at the base, and which may be armed apically with a narrow spine (with or without lateral spines); a convex epipygium that is uniformly punctate with a medial impunctate area, but without a transversely carinate apical margin; and the basiparameres not strongly developed ventroapically such that the ventroapical angle is well separated from the basal ring. *Chilothynnus* is distinguished from these genera by the combination of: a clypeus that has a well defined sagittal carina, and is narrowly produced and truncate apically; and a hypopygium that is acutely spinose laterally and rounded, truncate or pointed, but not spinose, apically.

The structure of the clypeus is similar in *Ariphron*, *Tachyphron* and *Tachynomyia*, and to a lesser extent *Agriomyia* in which the carina is not sharply defined. A poorly defined or incomplete carina also occurs in some species of *Neozeleboria* and *Phymatothynnus*. However, these genera have the hypopygium apically spinose as do all other genera in this group except *Psammothynnus* and *Zeleboria* (although the spine may be modified, or reduced to a small swelling of the apical margin in some *Phymatothynnus*).

A sagittal carina is also present in *Psammothynnus* and *Zeleboria*, but the clypeus is greatly swollen and broadly truncate (probably as a result of the swelling). Both also lack an apical spine on the hypopygium which is emarginate in *Psammothynnus*, and apically rounded and often with a small lateral spine in *Zeleboria*. Some additional differences between these two genera are discussed by Brown (1995). *Chilothynnus* may therefore be most closely related to *Zeleboria*.

The six species described here are similar in appearance. Typically they are black with orange legs, with a few small yellow marks on the head and mesosoma, and pale yellow lateral spots on some tergites. However, colour is variable between specimens. In *C. macraei* it is particularly variable with the metasoma frequently having a red background, while in *C. boweri* the legs may be almost black, and the head and body of *C. rossi* may be almost entirely black. *Chilothynus sandaracus* differs from the other species in that the basal three metasomal segments are orange, and metasomal spots are absent. Most species are known from relatively few specimens.

Relationships between the species are not clear due to the presence of very few morphological characters of diagnostic value. These are mostly limited to the shape of S8 and the genitalia. These include: spines on the trochanters and subparallel parameres in *C. trochanterinus*; a long apically filamentous aedeagus in *C. sandaracus*; a swollen aedeagus in *C. macraei*; and a tooth or small lobe on the ventral margin of the parameres in most species.

The majority of specimens examined here were collected by C.C. Bower using orchid baiting techniques which involve the exposure of orchid flowers for one to two minutes in potentially suitable habitats (Bower 1996). Attracted wasps are then collected by hand netting. Because most of the orchids listed here are translocated (that is, picked, moved to another location, and then exposed to the environment to attract potential pollinators), most of the associated wasps cannot be considered the natural pollinators of these flowers. The only species of wasp known to pollinate an orchid within its native range is *Chilothynnus palachilus* (which pollinated *Chiloglottis palachila*). Other known wasp-orchid attractions are: *C. palachilus* to translocated flowers of *C. chlorantha* and *C.* aff. *palachila*; *C. trochanterinus* strongly attracted to translocated *C.* aff. *palachila* and *C. chlorantha*; and *C. sandaracus* weakly attracted to *C. valida*.

Chilothynnus boweri, *C. macraei* and *C. rossi* are not known to be attracted to orchids, but all are known from only few specimens, most of which were collected in Malaise traps. Perhaps coincidentally, all three species are amongst the smallest known thynnines with a minimum known size of 4-5 mm. Previously only *Asthenothynnus* and *Gymnothynnus* were known to contain species of such small size.

Almost all remaining specimens were collected by Malaise trap on the adjoining properties of "Fairburn" and "Daisy Hill". Twenty traps were operated in remnant vegetation stands, and out into adjoining pasture between 8 August 1991 and 3 February 1994 (Campbell and Brown 1994). Of 4,638 tiphiids trapped during this period, only three *C. boweri*, eleven *C. macraei* and four *C. rossi* were collected. During much of this period the area experienced drought and this probably resulted in low numbers of catches. Despite the high number of Malaise traps, low numbers of *Chilothynnus* wasps were caught. This suggests that other species of tiphiids may have been present in the area, but were in such low numbers that none were caught.

Nothing is known of the biology of this genus other than that males are orchid pollinators.

The genus is known only from south-eastern Australia, with all records from eastern New South Wales except one each from Victoria and south-eastern Queensland. The orchid genus *Chiloglottis* has a similar range, but extends into south-eastern South Australia and Tasmania (Jones 1988). *Chilothynnus* may have a similar distribution. Jones also records this orchid from New Zealand, but its occurrence may be an introduction as there are no thynnine wasps occurring in that country (Given 1953).

The distributions of *C. palachilus* and *C. sandaracus* are sympatric in the New England National Park. Similarly *C. boweri*, *C. macraei* and *C. rossi* all occur at Wollomombi.

Although there are relatively few collection records, it would appear that adult males are on the wing as follows: *C. macraei* and *C. trochanterinus* from September to November; *C. palachilus* from November to January; *C. boweri* from November to March; *C. rossi* from December to January; and *C. sandaracus* from September to March.

Females are known only from two specimens of *C. trochanterinus* from Mullion Creek.

ACKNOWLEDGMENTS

I am indebted to Dr Col Bower (and several other orchid enthusiasts) for tirelessly collecting specimens, and for providing insights into their behaviour as orchid pollinators. The Wollomombi specimens were collected as part of a co-operative research project with Gus Campbell (N.S.W. Agriculture, Armidale) and funded by RIRDC. This funding is gratefully acknowledged, as is the unlimited access to the properties "Daisy Hill" and "Fairburn" by Malcolm Ross and Allan McRae respectively during that project.

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ARTHROTHYNNUS, A NEW GENUS OF ORCHID-POLLINATING THYNNINAE (HYMENOPTERA: TIPHIIDAE).

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ABSTRACT

Arthrothynnus gen. nov. is erected for six new species of Australian orchid-pollinating tiphiid wasps: *A. angustus* sp. nov., *A. huntianus* sp. nov., *A. latus* sp. nov., *A. nigricrus* sp.nov., *A. queenslandensis* sp. nov. and *A. rufiabdominalis* sp. nov. A key to males is given.

KEYWORDS: Tiphiidae, Thynninae, *Arthrochilus*, *Arthrothynnus* gen. nov., *Chiloglottis*, Australia, new genus, new species.

INTRODUCTION

Little has been published on the pollination of Australian orchids by thynnine (Tiphiidae: Thynninae) wasps. This literature has been reviewed, from a botanical perspective, by Armstrong (1979) and Adams and Lawson (1993), while Brown and Bower (unpublished manuscript), after examining all available material, record 91 species belonging to at least 19 thynnine genera (including *Arthrothynnus* gen. nov., *Neozeleboria* Rohwer, *Phymatothynnus* Turner, *Thynnoides* Guérin, *Zaspilothynnus* Ashmead, and an undescribed genus) as being attracted to orchids of the genera *Arthrochilus* F. Mueller, *Caladenia* R. Brown, *Chiloglottis* R. Brown, *Diuris* J.E. Smith, *Drakaea* Lindley, *Paracaleana* Blaxell, *Prasophyllum* R. Brown and *Spiculaea* Lindley.

There has been no work published specifically on the taxonomy of orchid-pollinating thynnine wasps. This, and the description of another new genus (Brown 1996), are the first of a several papers dealing with orchid pollinating taxa.

Five of the six species described here were attracted to terrestrial orchids (Orchidaceae: Drakaeinae) of the genera *Chiloglottis* and/or *Arthrochilus* using orchid baiting techniques as discussed by Bower (1992). Such techniques use orchid flowers which are picked and moved (translocated) to another location and used as bait to attract male tiphiids. Under such conditions, orchids may attract a number of species, which have been categorised by Bower (unpublished manuscript) as: "pollinator" (those species which have been observed to transfer pollen from one flower to another, thus fertilising it); "potential pollinator" (those sympatric species that show appropriate precopulatory or copulatory behaviour on the labellum of the orchid, and are of a suitable-size to contact the stigma with the mesosoma, but for which pollination has not been observed); and "minor responder" (those species that do not fulfil all of the requirements, whether physical or behavioural, for pollen transfer to occur). Baiting techniques may attract relatively large numbers of wasps.

Arthrothynnus gen. nov. is a genus of small wasps related to *Tmesothynnus* Turner, although it superficially resembles *Neozeleboria*.

Terminology follows Snodgrass (1941), Brown (1989) and Naumann (1991). Punctation is defined in Brown (1989).

Abbreviations. Morphological characters: T1-7, metasomal tergites 1-7; S1-8, metasomal sternites 1-8. Specimen repositories: AM, Australian Museum, Sydney; ANIC, Australian National Insect Collection, CSIRO, Canberra; BCRI, Biological and Chemical Research Institute, NSW Agriculture, Rydalmere; BMNH, The Natural History Museum, London; MV, Museum of Victoria, Melbourne; NTM, Museum and Art Gallery of the Northern Territory, Darwin; QM, Queensland Museum, Brisbane; SAM, South Australian Museum, Adelaide; WPS, W.P. Stoutamire collection, University of Ohio, Akron. Collectors: CCB, C.C. Bower.

SYSTEMATICS

Arthrothynnus gen. nov.

Type species: *Arthrothynnus huntianus* sp. nov.

Diagnosis. Clypeus narrowly truncate, weakly medially raised, not carinate. Antennal prominence above plane of clypeus, slightly medially emarginate. Maxillary palps 6-segmented, basal segment short, segments 2-3 and 5-6 subequal, segment 4 slightly longer. Labial palps 4-segmented, basal segment with dorsal and ventral fringes of setae, as long as segments 2 and 3 combined, 2 and 3 subequal in length, 4 slightly longer than 2 and 3. Pronotum with anterior margin slightly raised, not carinate. Propodeum oblique. Metasoma with segments polished, strongly constricted, and without spines. T7 with broad U-shaped apical carina, closely punctate laterally and dorsally, slightly flattened (less so medially) and impunctate posteromedially. S1 strongly medially raised, not carinate. S8 truncate with stout apical spine, lateral margins straight, parallel apically and ending in a small lateral spine or tooth. Genitalia with well developed basal ring, basiparameres dorsoapically emarginate, and parameres apically truncate.

Etymology. The generic name is based on that of the orchid genus *Arthrochilus* which is pollinated by the type species.

KEY TO MALES OF *ARTHROTHYNNUS* GEN. NOV.

1\. a Metasomal segments 2-3 red .... *A. rufiabdominalis* sp. nov.
   b Metasomal segments black 2
2\. a Legs black; head and mesosoma marked with pale creamy yellow; hind coxa with elongate yellow dorsal spot .... *A. nigricrus* sp. nov.
   b Legs mostly orange; head and mesosoma marked with bright yellow; hind coxa either black or with extreme apex yellow 3
3\. a Tegulae black ....*A. huntianus* sp. nov.
   b Tegulae orange or yellow 4
4\. a Parameres (in profile) narrow (Fig. 2) [usually: anterior margin of pronotum narrowly yellow (discontinuous medially), posterior margin black at least medially; disc of mesoscutum black (rarely with small yellow spot); trochanters orange] .... *A. angustus* sp. nov.
   b Parameres (in profile) broader (Figs 3,5) [usually: anterior and posterior margins of pronotum lined with yellow, and often confluent medially; disc of mesoscutum mostly yellow; trochanters black to orange] 5
5\. a Parameres as in Fig. 3 [at least fore trochanters darker than femora, usually black] .... *A. latus* sp. nov.
   b Parameres as in Fig. 5 [fore trochanters and femora orange] .... *A. queenslandensis* sp. nov.

Arthrothynnus huntianus sp. nov.
(Fig. 1)

Type material. HOLOTYPE male - NTM (I587): Mt Canobolas, New South Wales, attracted to *Chiloglottis trilabra* ex Batlow, 13 March 1993, CCB. PARATYPES - NEW SOUTH WALES: AM, BMNH (2 males): same data as holotype; BCRI (1 male): Cumberland Range, Adaminaby, 1988, G. Baker; NTM (1 male): Batlow Lookout Reserve, roosting on grass stem, late afternoon, 9 March 1988, CCB; AM, NTM (2 males): 1 km W of Batlow, attracted to *Arthrochilus huntianus* ex Batlow, 15 February 1989, CCB; AM, NTM (2 males): Blackbutt Mt, Sunny Corner State Forest, E of Bathurst, resting on grass and ferns, 6 March 1988, CCB; NTM (1 male): Kelly's Falls E of Helensburg, 11 October 1992, G. Brown and M. Terras; AM, ANIC, BCRI, NTM (4 males): Mt Canobolas, attracted to *Arthrochilus huntianus* ex 7km SSE of Mt Werong, 10 January 1988, CCB; AM, NTM (2 males): Towac entrace Rd, Mt Canobolas, swarming on grass tussock, 19 February 1989, CCB; AM, NTM (2 males): Mt Canobolas, attracted to *Chiloglottis trilabra* ex shale/sandstone Mt Werong, 3 March 1989, CCB; AM, ANIC, NTM (4 males): Mt Werong, attracted to *Arthrochilus huntianus*, 9 January 1988, CCB; NTM (1 male): 6 km E of Mt Werong, attracted to *Chiloglottis trilabra*, 5 March 1989, CCB; ANIC (1 male): Thredbo R., Mt Kosciusko, 3000 ft (914 m), 14 December 1931, R.L. Tonnoir; AM (1 male): 15 km SW of Nowra, 17 May 1982, G.J. and A. Holloway; AM, ANIC, BMNH, NTM (4 males): Rockley Mt, attracted to *Arthrochilus huntianus* ex 7 km SSE of Mt Werong, 9 January 1988, CCB; ANIC, BCRI, MV, NTM, QM (5 males): Oakey Ck, N Mullion Ra., attracted to *Arthrochilus huntianus* ex 7 km SSE of Mt Werong, 10 January 1988, CCB; AM, NTM (2 males): Vittoria, attracted to *Arthrochilus huntianus* ex 7 km SSE of Mt Werong, 9 January 1988, CCB; AUSTRALIAN CAPITAL TERRITORY: ANIC (1 male): Mt Gingera, 24.ii.1959, E.F. Riek; ANIC (1 male): Blundell's Camp, 4.i.1930, L. Graham; VICTORIA: ANIC (1 male): Grampians, attracted to *Arthrochilus huntianus*, 14 December 1977, W.P. Stoutamire; WPS (1 male): Portland, attracted to *Arthrochilus huntianus*, 13 December 1988, W.P. Stoutamire.

Description. Body length 7-10 mm; fore wing 6-8.5 mm; hind wing 4-6.5 mm. Clypeus closely and finely punctate. Frons rugosely punctate. Vertex closely punctate. Genae closely to rugosely punctate. Pronotum punctate medially becoming closely punctate laterally. Mesoscutum closely to rugosely punctate. Mesoscutellum closely punctate. Metanotum punctate. Propodeum transversely multistriate becoming reticulate near anterior margin. Fore coxae flat, obliquely truncate on apicomedial half, apex of truncation with fringe of long setae, lateral margin carinate apically. Mesopleura closely punctate. T1 as long as wide, sparsely punctate. T2-3 closely punctate basally, sparsely punctate apically. T4-6 closely punctate. Sternites closely punctate. Parameres with apex narrowly truncate and dorsal margin notched (Fig. 1C, D).

Colour. Black; mandibles, margin of clypeus, spot above antennal insertion, anterior margin of pronotum (narrowly interrupted medially), posterior margin of pronotum near tegulae, metanotum, and margins of mesosternal lamellae, yellow; legs (except coxae, trochanters and outer surface of hind tibiae), orange; small spot behind eye, tarsi, and outer surface of hind tibiae, brown. Wings weakly infuscate; veins dark brown. Setate white, pale yellow on frons and vertex.

Distribution. Coast, ranges and tablelands of central and southern New South Wales and Victoria.

Remarks. The yellow colouration may be absent on the clypeus (especially in smaller specimens), mandibles, and pronotum. Rarely the mesoscutellum has a small yellow spot.

This species is the pollinator of *Arthrochilus huntianus*, but is also attracted as a minor responder to *Chiloglottis trilabra*. The normal pollinator of *C. trilabra* Fitzg. is *Neozeleboria proxima* (Turner) (C.C. Bower, pers. comm.).

Arthrochilus huntianus is also recorded from Tasmania (Jones 1988), and is the only orchid of that genus to occur there. Perhaps surprisingly, the only records of *Arthrothynnus* from that state are two specimens of *A. latus*. It is unknown if *Arthrothynnus huntianus* occurs, or if, in its absence, the orchid is pollinated by *A. latus*. The former would appear more likely as: (1) there are relatively few tiphiid records from Tasmania; and (2) whilst it is probably unlikely that thynnine-pollinated orchids to occur naturally outside the range of the wasp, the converse is not true, and *A. latus* could occur there without an orchid to pollinate.

The pollination of *Arthrochilus huntianus* has been described by Rotherhan (1967). Although he believed the pollinator to be a species of *Rhagigaster*, the wasp drawn by him clearly is not of this genus, and is almost certainly that of the species described here. I have been unable to locate any specimens collected by Rotherhan.

Etymology. The species name is derived from the specific name of the orchid which this wasp pollinates.

Arthrothynnus angustus sp. nov.
(Fig. 2)

Type material. HOLOTYPE male - NTM (1588): Wonboyn Lake, S of Eden, New South Wales, attracted to *Chiloglottis diphylla* ex Bilpin Res., 4 April 1994, CCB. PARATYPES - NEW SOUTH WALES: ANIC, BMNH (2 males): same data as holotype; AM (1 male): Burralow Swamp, Blue Mountains NP, 9 December 1986, G.A. Holloway; NTM (1 male): Hartley Pass, 5 km N of Mt Victoria, attracted to *Chiloglottis diphylla* ex Mt Murray E of Robertson, 27 February 1994, CCB; AM (1 male): Iluka Nature Res., Clarence R., 30 January 1983, D.K. McAlpine and K.C. Khoo; NTM (1 male): Gillard Bch, Mimosa Rocks NP, Tanja, attracted to *Chiloglottis diphylla* (large form) ex Bilpin Res., 3 March 1994, CCB; AM (1 male): Mt Keira, 23 February 1983, G.A. Holloway; AM (1 male): Nerong SF, 3 Decem-

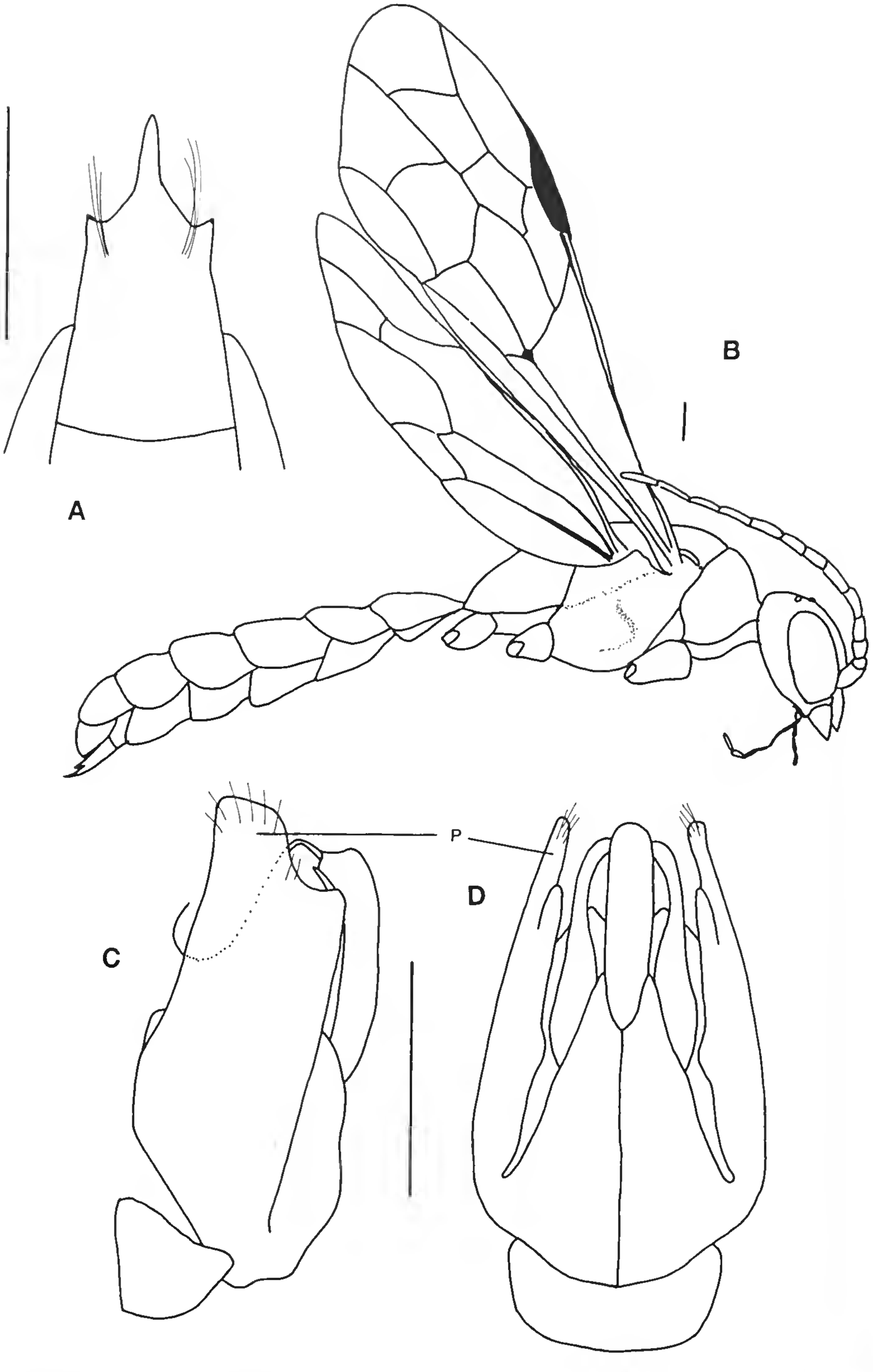

Fig. 1. *Arthrothynnus huntianus* sp. nov.: **A**, hypopygium; **B**, habitus; **C**, genitalia, lateral view; **D**, genitalia, dorsal view. Scale lines = 0.5 mm; p = parameres.

ber 1987, D.J. Scambler; AM (1 male): Royal NP, 7 February 1978, M.A. Schneider; AM (1 male): "Tuglo", 48 km N of Singleton, 17 December 1981, G.A. Holloway; NTM (2 male): Styx R. State Forest, possibly attracted to *Chiloglottis diphylla*, 24 February 1993, CCB; UQIC (1 male): Tooloom Plateau via Urbenville, 600-700 m, long grass, wet sclerophyll forest, 24 February 1974, I.D. Naumann; CCB collection (2 males): Zircon Ck, Mt Wilson, attracted to *Chiloglottis diphylla* ex Bilpin, 27 February 1993, CCB. QUEENSLAND: UQIC (1 male): Cunningham's Gap NP, 25 January 1966, T. Weir; UQIC (3 males): Upper Clayton Gully nr Cunningham's Gap, 400-600 m, 25 April 1974, I.D. Naumann; UQIC (2 males): Teviot Brook, nr Wilson's Peak, 153°31'E, 28°13'S, 17-18 October 1980, G. Daniels and M.A. Schneider; UQIC (1 male): Mt Glorious, 15 January 1963, T. Brooks; UQIC (1 male): Woodford, 26 February 1965, F.D. Page.

Description. Body length 9-10 mm; fore wing 7-8 mm; hind wing 5-5.5 mm. Clypeus closely and finely punctate. Frons rugosely punctate. Vertex closely and finely punctate. Genae rugosely and finely punctate. Pronotum closely to rugosely punctate. Mesocutum closely to rugosely punctate. Mesoscullum closely punctate. Metanotum punctate. Propodeum transversely multistriate becoming reticulate near anterior margin. Fore coxae flat, obliquely truncate on apicomedial third, apex of truncation with fringe of long setae, lateral margin not carinate. Mesopleura closely punctate becoming rugosely punctate dorsally. T1 as long as wide, sparsely punctate. T2-5 closely and finely punctate becoming sparsely punctate apically. T6 closely and finely punctate. Sternites closely punctate. Parameres with apex narrowly truncate, dorsal margin not notched (Fig. 2A, B).

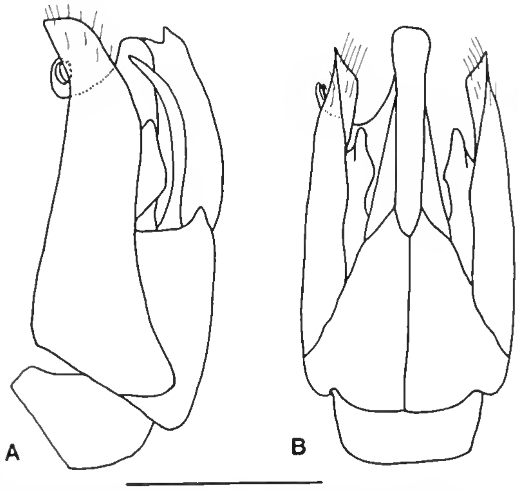

Fig. 2. *Arthrothynnus angustus* sp. nov.: A, genitalia, lateral view; B, genitalia, dorsal view. Scale lines = 0.5 mm.

Colour. Black; clypeus, inner orbits of eye ventrally, spot above antennal insertion, anterior margin of pronotum (narrowly interrupted medially), posterior margin near tegulae, small spot on mesocutellum (often indistinct) and metanotum, yellow; mandibles, antennae, tegulae, and legs (except coxae), orange; small spot behind eye, brown. Wings weakly infuscate; veins dark brown to black becoming orange basally. Setae white.

Distribution. Coast and ranges of New South Wales and south-eastern Queensland.

Remarks. The flagellum varies from orange (especially ventrally) to black while the mesosternal lamellae may be testaceous, black, or margined with yellow.

This species is a pollinator of *Chiloglottis diphylla* R.Br. (C.C. Bower, pers. comm.), but although the orchid species and the wasp species occupy overlapping geographical ranges, all records are for translocated flowers.

Etymology. The species name is derived from the Latin and refers to the narrowness of the parameres of the male genitalia.

Arthrothynnus latus sp. nov.
(Fig. 3)

Type material. HOLOTYPE male - NTM (I589): "Kooroo", Mullion Ck, 21km N of Orange, New South Wales, attracted to *Chiloglottis diphylla* ex Seven Mile Beach, 26 March 1994, CCB. PARATYPES - NEW SOUTH WALES: ANIC, BMNH (2 males): same data as holotype; NTM (1 male): Cathedral Rocks NP, attracted to *Chiloglottis diphylla* ex Styx R., 28 March 1993, CCB; NTM (1 male): Cathedral Rocks NP, attracted to *Chiloglottis pluricallata* ex Mt Carson, Barrington Tops, 31 December 1993, CCB; AM (1 male): Mt Kaputar, c.1370 m, 14 January 1978, G. Daniels; AM, ANIC, BCRI, NTM (9 males): Mullion Ck, attracted to *Chiloglottis diphylla* ex Bilpin, 14 March 1993, CCB; AM, ANIC, BCRI, NTM (6 males): Mullion Ck, attracted to *Chiloglottis diphylla* ex Styx R. NP, 3 April 1993, CCB; AM, ANIC, BCRI, QM, NTM (6 males): "Kooroo", Mullion Ck, 21 km N of Orange, attracted to *Chiloglottis diphylla* ex Mt Murray, 20 February 1994, CCB; AM, ANIC, NTM, SAM (4 males): "Kooroo", Mullion Ck, 21km N of Orange, attracted to *Chiloglottis anaticeps* ex Armidale-Grafton rd, 4.5 km E of Pt Lookout turnoff, 1 March 1994, CCB; NTM (1 male): "Kooroo", Mullion Ck, 21 km N of Orange, attracted to *Chiloglottis anaticeps* ex Grass Tree Picnic Area, Werrikimbe NP, NW of Wauchope, 1 March 1994, CCB; NTM (1 male): "Kooroo", Mullion Ck, 21 km N of Orange, attracted to *Chilglottis seminuda* ex Fitzroy Falls W of Roberston, 1 March 1994, CCB; AM, ANIC, MV, NTM (7 males): "Kooroo", Mullion Ck, 21 km N of Orange, attracted to *Chilglottis diphylla* ex Bilpin Res., 26 March 1994, CCB; AM, ANIC, BCRI, BMNH, MV, NTM, QM, SAM (33 males): "Kooroo", Mullion Ck, 21 km N of Orange, attracted to *Chiloglottis diphylla* ex Bilpin Res., 1 March 1995, CCB; AM, ANIC, BCRI, BMNH, NTM (7 males): Serpentine Nature Reserve, attracted to *Chiloglottis diphylla* ex Styx R., 28 March 1993, CCB; CCB collection (1 male): "Kooroo", Mullion Ck, 23 km N of Orange, 26 March 1995, CCB; NTM (1 male): Serpentine Nature Reserve, attracted *Chiloglottis pluricallata* ex Mt Carson, Barrington Tops, 31 December 1993, CCB; AM, ANIC, NTM (3 males): Serpentine Nature Reserve, attracted to *Chiloglottis pluricallata* ex Barrington Tops, 1 January 1995, CCB; BCRI (1 male): "Daisy Hill", 11.5 km NE of Wollomombi, 152°10'E, 30°27'S, 29 July 1993 (R1), A. Campbell & C. Haywood; NTM (1 male): "Fairburn", 13.6 km NE of Wollomombi, 152°10'E, 30°27'S, 2 December 1993 (M29), A. Campbell and C. Haywood. TASMANIA: UQIC (1 male): Murdunna, Forestier Peninsula, on *Bursaria spinosa* 4 January 1969, E.M. Exley; UQIC (1 male): Port Arthur, 4 January 1969, on *Leptospermum* sp., E.M. Exley.

Description. Body length 6-13 mm; fore wing 4.5-9 mm; hind wing 3.5-7 mm. Clypeus closely and finely punctate. Frons rugosely punctate. Vertex closely and finely punctate. Genae rugosely and finely punctate. Pronotum closely punctate. Mesoscutum closely to rugosely punctate. Mesoscutellum closely punctate. Metanotum punctate. Propodeum transversely multistriate becoming reticulate near anterior margin. Fore coxae flat, obliquely truncate on apicomedial third, apex of truncation with fringe of long setate, lateral margin not carinate. Mesopleura closely punctate becoming rugosely punctate dorsally. T1 as long as wide, sparsely punctate. T2-6 closely and finely punctate. Sternites closely punctate. Parameres with apex broadly truncate, dorsal margin not notched (Fig. 3A, B).

Colour. Black; mandible, clypeus, inner orbits of eye ventrally, spot above antennal insertion, anterior and posterior margins (often confluent medially) of pronotum, large spot on mesoscutellum, and metanotum, yellow; antennae, tegulae, and legs (except coxae and trochanters), orange; small spot behind eye brown. Wings hyaline; veins brown to black becoming orange basally. Setae white, pale yellow on frons and vertex.

Distribution. Ranges and tablelands of New South Wales, with two records from Tasmania.

Remarks. The yellow colouration may be reduced on the clypeus (to the margins in smaller specimens) and mesoscutellum, and interrupted medially on the pronotum. The reduction in colouration on the mesoscutellum is particularly noticeable on northern specimens (Cathedral Rocks, Serpentine River and Wollomombi), while a single specimen from Mullion Ck (14 March 1993) has small lateral yellow marks on T2-4. Orange colouration may be absent or reduced on the antennae and trochanters (especially fore trochanters which are darker than the femora). Mesosternal lamellae may be testaceous, black, or margined with yellow.

This species is the pollinator of *Chiloglottis diphylla* and a minor responder to *C. anaticeps*, *C. pluricallata* and *C. seminuda*. Although all records for *C. diphylla* are for translocated flow-

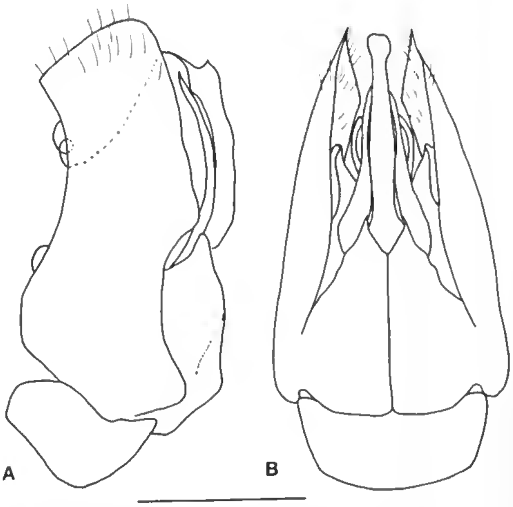

Fig. 3. *Arthrothynnus latus* sp. nov.: A, genitalia, lateral view; B, genitalia, dorsal view. Scale lines = 0.5 mm.

ers, the wasp and orchid have overlapping distributions (C.C. Bower, pers. comm.).

Etymology. The species name is derived from the Latin and refers to the broadness of the parameres of the male genitalia.

Arthrothynnus nigricrus sp. nov.
(Fig. 4)

Type material. HOLOTYPE male - NTM (I590): Cairncross SF, 10 km NW of Port Macquarie, New South Wales, attracted to *Chiloglottis pluricallata* ex Mt Carson, Barrington Tops, 29 December 1993, CCB. PARATYPE - NTM (1 male): same data as holotype.

Description. Body length 9 mm; fore wing 7 mm; hind wing 5 mm. Clypeus closely and finely punctate. Frons rugosely punctate. Vertex and genae closely and finely punctate. Pronotum closely to rugosely punctate. Mesoscutum rugosely punctate. Mesoscutellum closely punctate. Metanotum punctate. Propodeum transversely multistriate becoming reticulate anteriorly. Fore coxae weakly convex becoming shallowly concave apically, without fringe of setae, lateral margin not carinate. Mesopleura closely punctate becoming rugosely punctate dorsally. T1 longer than wide, sparsely punctate. T2-5 sparsely punctate. T6 sparsely punctate becoming closely punctate posteriorly. Sternites closely punctate. Parameres with apex broadly truncate, dorsal margin notched (Fig. 4A, B).

Colour. Black; mandibles, margin of clypeus, inner orbits of eye ventrally, spot above antennal insertion, anterior margin of pronotum (narrowly interrupted medially), posterior margin near tegulae, spot below fore wing, metanotum, margins of mesosternal lamellae, and elongate dorsal spot on hind coxae, pale yellow; small spot behind eye, fore tarsi, and inner surface of fore tibia, brown. Wings hyaline; veins dark brown to black. Setae white.

Distribution. Known only from the north coast of New South Wales.

Remarks. This species is an allopatric minor responder to *Chiloglottis pluricallata*.

Etymology. The species name is derived from the Latin and refers to the black legs.

Arthrothynnus queenslandensis sp. nov.
(Fig. 5)

Type material. HOLOTYPE male - QM: 7 km NE of Tolga, Queensland, light trap, April 1987, Storey and De Faveri. PARATYPES - QUEENSLAND: UQIC (1 male): Brisbane, 7 October 1979, H.E. and M.A. Evans; UQIC (1 male): Carnarvon National Park, 8-10 December 1979, M.A. Schneider and G. Daniels; NTM (1 male): Petrie, 4 December 1962, I.C. Yeo.

Description. Body length 9 mm; fore wing 7 mm; hind wing 5 mm. Clypeus closely and finely punctate. Frons rugosely punctate. Vertex closely and finely punctate. Genae rugosely and finely punctate. Pronotum, mesoscutum and mesoscutellum rugosely punctate. Metanotum closely punctate. Propodeum rugosely punctate becoming reticulate near anterior margin. Fore coxae flat, obliquely truncate on apicomedial third, apex of truncation with fringe of long setae, lateral margin not carinate. Mesopleura rugosely punctate. T1 as long as wide. Tergites

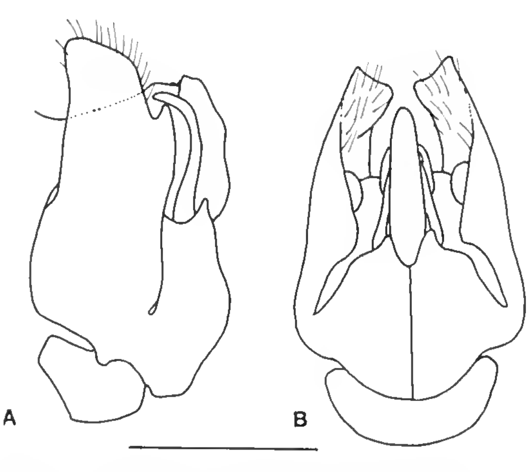

Fig. 4. *Arthrothynnus nigricrus* sp. nov.: A, genitalia, lateral view; B, genitalia, dorsal view. Scale lines = 0.5 mm.

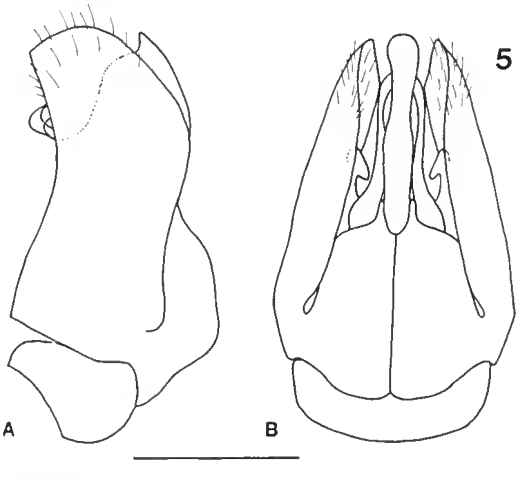

Fig. 5. *Arthrothynnus queenslandensis* sp. nov.: A, genitalia, lateral view; B, genitalia, dorsal view. scale lines = 0.5 mm.

and sternites closely punctate. Parameres with apex truncate, dorsal margin not notched (Fig. 5A, B).

Colour. Black; mandible, clypeus, inner orbits of eye ventrally, spot above antennal insertion, anterior and posterior margins (confluent medially) of pronotum, large spot on mesoscutellum, and metanotum, lateral spot on propodeum, margins of mesosternal lamellae and extreme apex of mid and hind coxa, yellow; antennae, tegulae, and legs (except coxae), orange; small spot behind eye, brown. Wings hyaline; veins, orange. Setae white, pale yellow on frons and vertex.

Distribution. Northern to south-eastern Queensland.

Remarks. Southern Queensland specimens resemble *A. angustus* in colour, with yellow reduced or absent on, much of the clypeus, posterior margin of the pronotum, mesoscutellum, and propodeum.

This may be the pollinator of *Arthrochilus dockrillii* Lavarack which occurs in north-eastern Queensland and New Guinea (Jones 1988).

Etymology. The species name is derived from the general area of the type locality.

Arthrothynnus rufiabdominalis sp. nov.
(Figs 6, 7)

Type material. HOLOTYPE male - NTM, (I592): Wide Bay area, Queensland, pollinating *Arthrochilus irritabilis*, 27 November 1995, A. Logan. PARATYPES - QUEENSLAND: AM, ANIC, BMNH, MV, NTM, QM (9 males): same data as holotype; ANIC (1 male): Bundaberg, August - September 1971, H. Frauca; QDPI (1 male,) Tolga, at light trap, 21 November 1986, J. D. Brown; UQIC (2 males): Milmerran, on *Eucalyptus*, 6 November 1981, E. M. Exley and J. King; BMNH, NTM (4 males): Wide Bay area, pollinating *Arthrochilus irritabilis*, 17 November 1995, A. Logan.

Description. Body length 9-11 mm; fore wing 5-7 mm; hind wing 3-5 mm. Clypeus closely and finely punctate. Frons rugosely punctate. Vertex closely punctate. Genae, pronotum and mesoscutum closely to rugosely punctate. Mesocutellum rugosely punctate. Metanotum punctate. Propodeum transversely multistriate becoming reticulate near anterior margin. Fore coxae weakly convex becoming flat on apical half, flat area densely setose without distinct fringe, lateral margin not carinate. Mesopleura closely to rugosely punctate. T1 as long as wide, sparsely punctate. T2-6 closely punctate basally, sparsely punctate apically. Sternites closely and shallowly punctate. Parameres with apex narrowly truncate and dorsal margin notched (Fig. 6A, B).

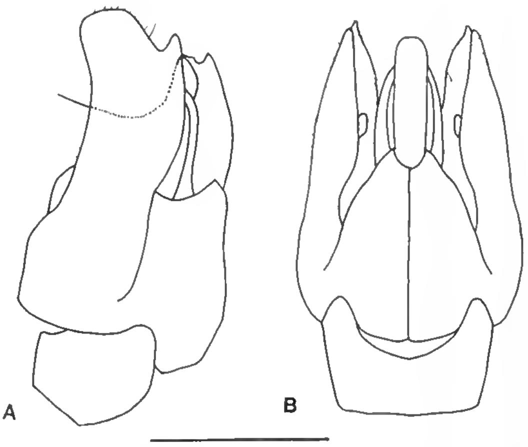

Fig. 6. *Arthrothynnus rufiabdominalis* sp. nov.: A, genitalia, lateral view; B, genitalia, dorsal view. Sclae lines = 0.5 mm.

Colour. Black; mandibles, clypeus (except medially), spot above antennal insertion, anterior margin of pronotum (narrowly interrupted medially), posterior margin of pronotum (interrupted medially), sagittal line on mesoscutellum, metanotum, and margins of mesosternal lamellae, dorsal margin of hind coxae, yellow; tegulae and legs (except coxae, trochanters and base of femora), orange; small spot behind eye, tarsi, and outer surface of tibiae, brown; T2-4, S2-4 and apex of T1, red. Wings hyaline; veins brown. Setae white.

Distribution. Known only from north and south-eastern Queensland.

Remarks. Yellow colouration may be more extensive on the pronotum while the red colouration may be absent from T1, T4 and S4.

This species is the pollinator of *Arthrochilus irritabilis* F. Mueller which ranges from New Guinea to north-eastern Queensland and south to the central coast of New South Wales (Jones, 1988). The wasp, although only recorded from Queensland, probably has a distribution similar to that of the orchid.

The thynnine fauna of New Guinea is poorly known, with most described species being large and conspicuous. It is unknown if this small and relatively inconspicuous species occurs, but it, or a closely related wasp species would probably be necessary for the occurrence of the orchid in New Guinea.

Fig. 7. *Arthrothynnus rufiabdominalis* sp. nov. pollinating *Arthrochilus irritibilis* orchids.

Etymology. The species name is derived from the Latin and refers to the colour of the metasoma (abdomen).

DISCUSSION

The six species described here are similar in appearance. They exhibit similar colour patterns and lack morphological characters of diagnostic value other than distinctive male genitalia.

The colouration of *A. nigricrus* differs from all other species of *Arthrothynnus* in that the legs are black, and pale markings are a pale creamy yellow, rather than orange and brighter yellow respectively. This species is probably most closely related to *A. huntianus* as both species have the dorsal margin of the parameres characteristically lobed. Both species also have the tegulae black rather than orange or yellow as in all other species.

The colouration of *A. rufiabdominalis* is also distinctive in that metasomal segments 2-4 are red. The dorsal margin of the parameres are also notched, but they are long and narrow, and resemble those of *A. angustus* which have been widened basally and notched dorsally.

The colour pattern of *A. queenslandensis* is variable, with the holotype from north Queensland resembling *A. latus*, while the three specimens from southern Queensland are similar to *A. angustus*. The genitalia of *A. queenslandensis* and *A. latus* are similar in that the parameres are relatively broad, as they are in *A. nigricrus* and *A. huntianus*, but not dorsally lobed as in the latter two species.

A. angustus has long narrow parameres, and is probably most closely related to *A. rufiabdominalis*.

Arthrothynnus is grouped with the genera *Encopothynnus* Turner, *Iswaroides* Ashmead, *Acanthothynnus* Turner, *Doratithynnus* Turner, *Aspidothynnus* Turner, *Gymnothynnus* Turner, *Epactiothynnus* Turner and *Tmesothynnus* Turner. These genera are distinguished from all other Australian Thynninae by the combination of: a relative short weakly protruding hypopygium that is not broadened and lobed or spined at the base, and which is armed apically with a narrow or broader testaceous spine (with or without small lateral spines); the epipygium weakly flattened apically with the apical margin carinate; the metasomal segments constricted; and the basiparameres angled and separated from the basal ring ventrobasally. *Arthrothynnus* is distinguished from these genera by the clypeus which is narrowly truncate and weakly medially raised, the antennal promience which is above the plane of the clypeus, and the truncated parameres. It is closest to *Tmesothynnus* in that the hypopygium is similarly shaped, and the metasoma is usually black.

The remaining genera of this group are distinguished by the following characters: spines on the tergum in *Encopothynnus*; spines on the sternum in *Iswaroides*, *Acanthothynnus* and *Doratithynnus*; an elongate-fusiform metasoma, and a swollen, produced and broadly apically truncate clypeus in *Aspidothynnus*; a short fusiform metasoma, and testaceous and often flattened hypopygial spines in *Gymnothynnus*; and a triangular hypopygium in *Epactiothynnus*.

Arthrothynnus is superficially similar to *Neozeleboria* in that the antennal prominence is above the plane of the clypeus, but the latter has the apical maxillary palp segments lengthened, the hypopygium triangular, rounded or subparallel and truncate, but with a single apical spine without lateral spines or teeth, and does not have the metasomal segments constricted.

The genus is only recorded from eastern Australia, with most specimens having been collected by C.C. Bower in eastern New South Wales, although *A. queenslandensis* and *A. rufiabdominalis* occur in both northern and south-eastern Queensland. There are two records of *A. huntianus* from Victoria, and two records of *A. latus* from Tasmania. All species except *A. queenslandensis* are recorded as pollinators of orchids of the genera *Arthrochilus* and *Chiloglottis* which occur in eastern Australia. A further two species of *Arthrochilus* occur in the Northern Territory, but their pollinators are as yet unknown.

Nothing is known about the biology of this genus other than that males are orchid pollinators.

ACKNOWLEDGMENTS

The majority of material has been provided by orchid enthusiasts, particularly Dr Col. Bower, to whom I am indebted. This work was also partially funded by the Australian Orchid Foundation. The operation of the Malaise traps at Wollomombi was part of a co-operative research project with Gus Campbell, and was funded by RIRDC. The photograph of *Arthrothynnus rufiabdominalis* was brought to my attention by Alan Logan and was taken from a colour slide by E.C.J. (Ted) Smith. It forms part of the A.N.O.S. Wide Bay Group's terrestrial slide library, and is reproduced with permission of the Group. Alan Logan also collected most of the type specimens of this species.

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NEW SPECIES OF *GALUMNA* HEYDEN, 1826 (GALUMNOIDEA) AND *PARAKALUMMA* JACOT, 1929 (ORIPODOIDEA), FROM THE NORTHERN TERRITORY, AUSTRALIA (ACARI: ORIBATIDA).

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ABSTRACT

New species of oribatid mites, *Galumna calva* n. sp. (Galumnidae) and *Parakalumma headlandi* n. sp. (Parakalummidae), from the soils of northern Australia, are described and figured. *Galumna triquetra* Aoki and *Pergalumna filifera* Mahunka are recorded from Australia for the first time.

KEYWORDS: oribatid mites, taxonomy, new species, Galumnidae, Parakalummidae, Northern Territory, Australia.

INTRODUCTION

The oribatid (Oribatida) mite fauna of Australia is very poorly known. Only nine species in the family Galumnidae (Galumnoidea) and one in the genus *Neoribates* Berlese from the family Parakalummidae (Oripodoidea) have been previously recorded from the Australian Capital Territory, Queensland and New South Wales (Balogh and Mahunka 1978; Balogh and Balogh 1983; Balogh 1985; Banks 1916). The oribatid fauna, especially of the families Galumnidae and Parakalummidae, of the Northern Territory is effectively unknown.

The present contribution, consisting of new records of two species, and descriptions of two new species, is based on material collected in rain forest soils in and near Darwin by Dr M.B. Malipatil during 1982. The material is preserved in ethanol and lodged with the Museums and Art Galleries of the Northern Territory (NTM) and the Institute of Soil Biology, České Budějovice, Czech Republic (ISB).

SYSTEMATICS

Galumnoidea
Galumnidae
Galumna calva n. sp.
(Figs 1A-C, 2A-D)

Type material. HOLOTYPE - NTM A82, Australia, Northern Territory, Darwin, 20 December 1982, rain forest, litter and soil sample, coll. M.B. Malipatil. PARATYPES - eight specimens (7 specimens, NTM A83 to A89 inclusive; 1 specimen, ISB), same data as holotype; two specimens (1 specimen, NTM A90; 1 specimen, ISB), Berry Springs (12°42'S, 130°58'E), 9 January 1982, rain forest, litter sample, coll. M.B. Malipatil

Diagnosis. Smooth pointed lanceolate sensillus, distinct interlamellar setae shorter than lamellar ones, dorsosejugal suture interrupted, elongate areae porosae adalares.

Description. Length of body 480-600 µm, mean 580 µm; width of body 407-537 µm. Colour light brown.

Prodorsum (Figs 1A, 2A). Rostrum rounded with smooth rostral setae (ro = 42 µm) as long as lamellar ones (la = 42 µm). Short and smooth interlamellar setae (in = 13 µm), approximately three times shorter than lamellar setae. Long lanceolate sensillus (S = 177 µm), 14 times longer than interlamellar ones, with long stalk and slender smooth, pointed head on apical quarter. Distinct elongated areae porosae dorsosejugalis. Sutura dorsosejugalis interrupted in middle part, observable only laterally. Entire surface of prodorsum smooth without distinct sculpturae.

Notogaster (Fig. 1A). Comparatively broad, smooth without distinct sculpturees, areae porosae adalares (Aa) ribbon-shaped. Two pairs of areae porosae mesonoticae (A_{1-2}) comparatively large and oval. Areae porosae posteriores A_3 elongated and larger than A_{1-2}. Areae porosae postanalis large and elongated. Lyrifissures ih, ips, im, and ip in usual position, comparatively small, median pore mp present. Pteromorphae

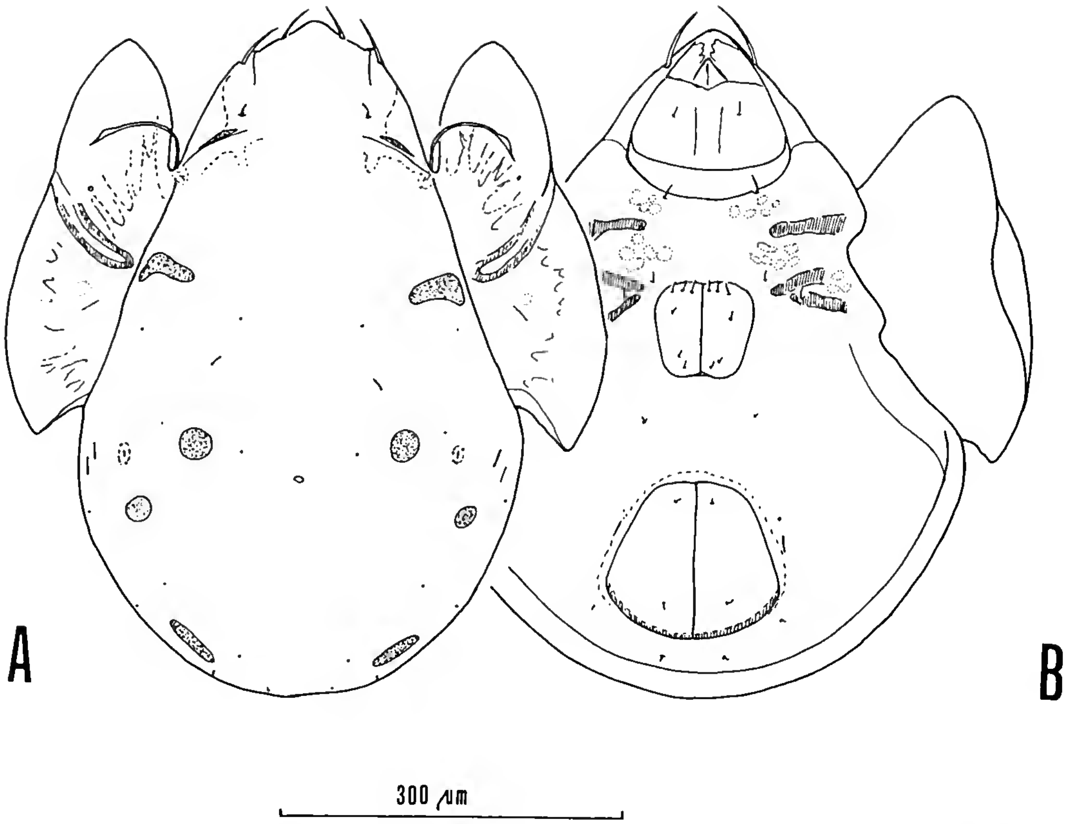

Fig 1. *Galumna calva* n. sp. **A**, dorsal side of the body without legs; **B**, ventral side of the body without legs. Scale, 300 µm.

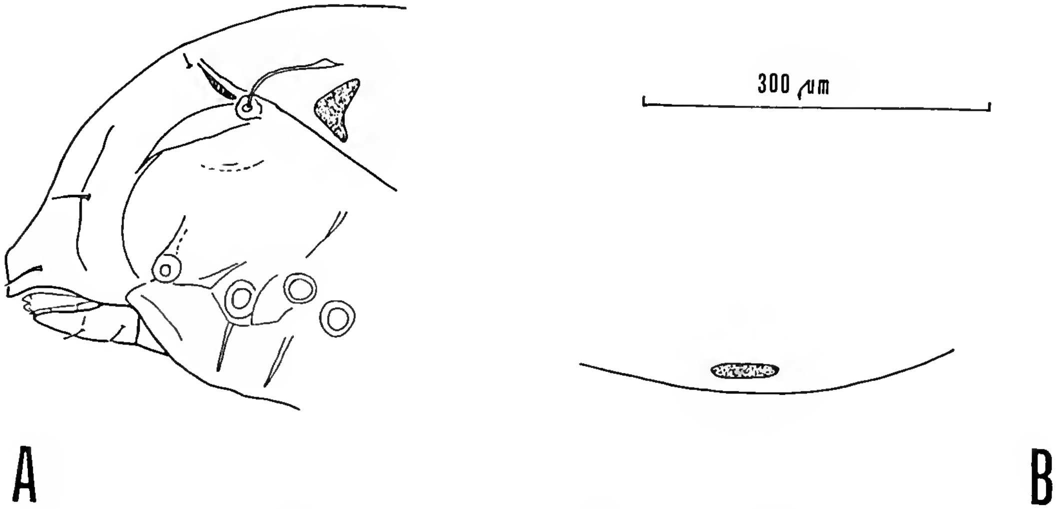

Fig 2. *Galumna calva* n. sp. **A**, lateral side of prodorsum; **B**, area porosae postanalis. Scale, 300 µm.

smooth with distinct lyrifissure ia or insertion of ta seta. Pteromorphal notch distinct, long, reaching to half of pteromorphal width.

Epimeral region (Fig. 1B). Surface with small light maculae. Epimerae I and II fused. Distinct epimeral setae 1b, 2b, 4a, and 4b.

Ventral plates (Fig. 1B). Anal plates more than two times longer, and wider than genital ones. Lyriffisures iad in adanal position. Circumpedial line long and distinct. Six pairs of fine genital setae, one pair of aggenital, two pairs of anal and three pairs of adanal setae.

Legs. All tridactylous, median claw stronger and longer than lateral ones. Leg chaetotactic formulae I 0-3-2(1)-4(2)-20(2)-3, II 0-3-2(1)-3(1)-15(2)-3, III 1-2-1(1)-3(1)-15-3, IV 1-2-2-3(1)-12-3. Entire leg surface smooth without distinct crests and ridges.

Remarks. The new species belongs to the *Galumna* species-group characterized by having lanceolate sensilli, distinct interlamellar setae shorter than lamellar setae, with areae porosae adalares elongated and without a complete dorsosejugal suture. *Galumna grandjeani* Balogh, 1962, has distinctly longer interlamellar setae and a pointed rostrum. It has similar sensilli shape but with a rough head (Balogh 1962).

A similar Australian species, *Galumna hammerae* Balogh, 1985, differs in having longer interlamellar setae, clavus of sensillus rough, and areae porosae mesonoticae (A_{1-2}) and posteriores (A_3) smaller (Balogh 1985). *Galumna longiporosa* Choi, 1986, from South Korea, has longer interlamellar setae and rough sensillar head (Choi 1986). *Galumna arabica* Bayoumi and Al Khalifa, 1984, has dorsosejugal sutura complete and longer interlamellar setae (Bayoumi and Al Khalifa 1984). *Galumna dispar* Willmann, 1931, has longer interlamellar setae and dorsosejugal sutura complete (Willmann 1931). *Galumna medius* Berlese, 1914, has a different shaped sensillus, dorsosejugal sutura complete and interlamellar setae longer (Berlese 1914).

Etymology. *Calva* (Latin) - bald head or skull, alluding to the shape and smoothness of the animal.

Galumna triquetra Aoki, 1965

Distribution. Thailand (Aoki 1965).

Material examined. One specimen (ISB), Australia, Northern Territory, Darwin, 20 December 1982, rain forest, rotting log, coll. M.B. Malipatil; one specimen (NTM), Darwin, 16 December 1982, rain forest, litter sample, coll. M.B. Malipatil.

Pergalumna filifera Mahunka, 1978

Distribution. Mauritius (Mahunka 1978).

Material examined. Three specimens (two specimens, NTM; one specimen, ISB) Australia, Northern Territory, Berry Springs, 12°42'S, 130°58'E, 9 January 1982, rain forest, litter sample, coll. M.B. Malipatil.

Oripodoidea

Parakalummidae

Parakalumma headlandi n. sp.

(Fig. 3A-D)

Type material. HOLOTYPE - NTM A91, Australia, Northern Territory, Darwin, 20 September 1982, rain forest, rotting log, coll. M.B. Malipatil. PARATYPES - one specimen (NTM A92), same data as holotype; two specimens (1 specimen, NTM A93; 1 specimen, ISB) from same locality as holotype, but collected on 20 December 1982; two specimens (1 specimen, NTM A94; 1 specimen, ISB) from Berry Springs (12°42'S, 130°58'E), 9 January 1982, rain forest, moss sample, coll. M.B. Malipatil.

Diagnosis. Rostral projection beak-like, five pairs of genital setae, adanal setae ad_2 in postanal position, interlamellar setae longer than sensillus.

Description. Length of body 543 - 602 µm, mean 565 µm; width of body 385 - 433 µm, mean 402 µm. Colour light brown. Surface of the body smooth without distinct sculpturing, with thin layer of cerotegument.

Prodorsum (Fig. 3A,C,D). Rostrum from anterolateral side somewhat narrow, with nasute projection with rounded tip. Pigmentation weak in rostral area, rostrum curved on ventral side from lateral view, extended to beak-like projection. Strong rostral setae barbed laterally. Lamellar and interlamellar setae approximately same length, two times longer than rostral setae. Cup-shaped bothridium with clavate sensillus gradually extending into elongated head, pointed distally, and weakly barbed on anterior third. Well-developed lamellae reaching half length of prodorsum not connected by translamella.

Notogaster (Fig. 3A). Smooth with four pairs of saccules with Sea largest. Ten pairs of alveoli of notogastral setae visible. Four pairs of lyrifissures im, ih, ips, ip as well as notogastral gland openings (Gla) present. Pteromorphae with

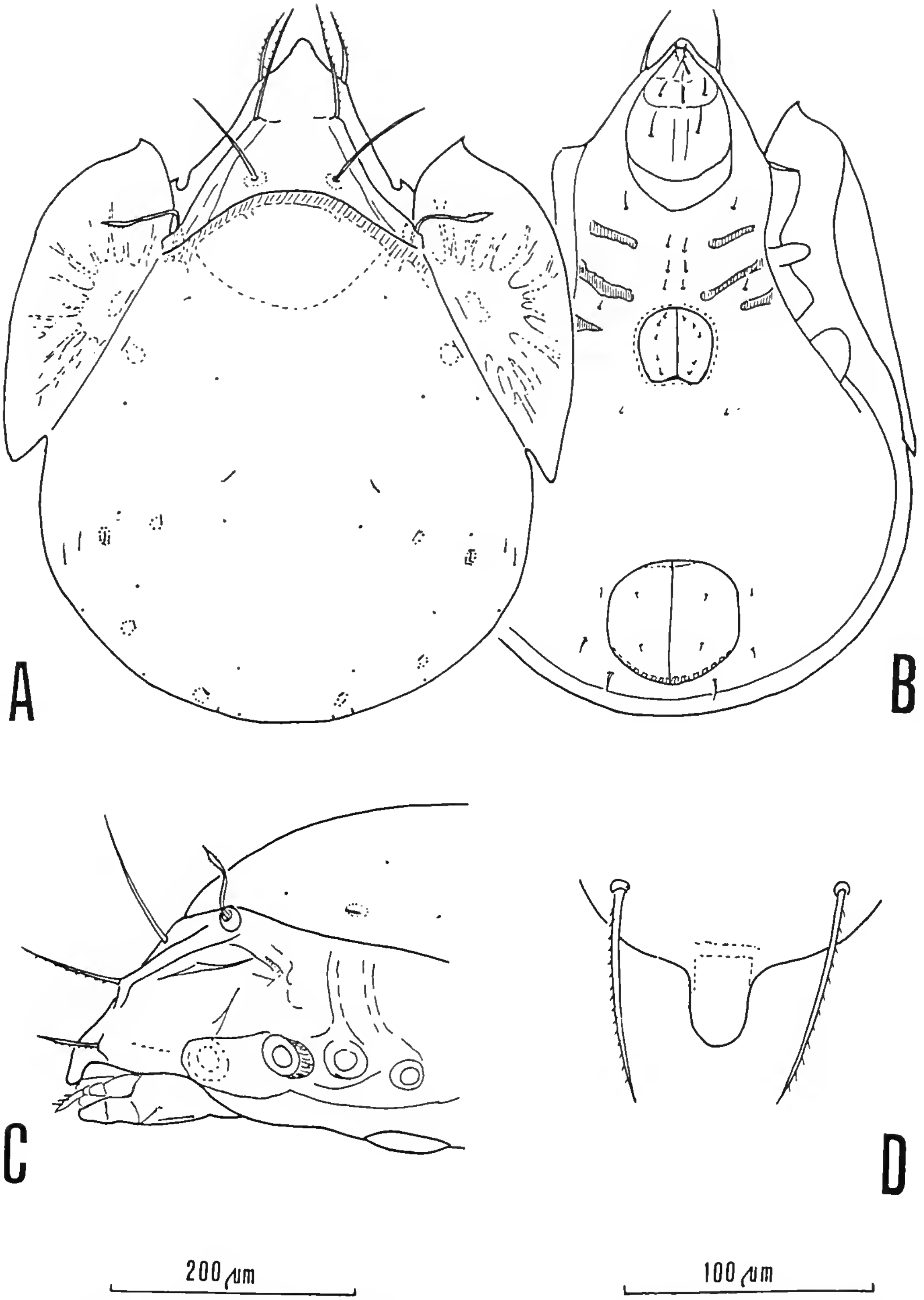

Fig 3. *Parakalumma headlandi* n. sp. **A**, dorsal side of the body without legs; **B**, ventral side of the body without legs; **C**, lateral side of prodorsum without pteromorphae; **D**, rostrum in frontal view. Scale for A - C, 200 µm; for D, 100 µm.

sharp anterior tip, sometimes with two to three small sharp teeth.

Epimeral region (Fig. 3B). Entire surface smooth, epimeral setae formula 2-0-2-3; all epimeral setae smooth.

Ventral plates (Fig. 3B). Smooth; circumpedial carina long reaching level of pedotecta I. Rounded genital plates with five pairs of smooth and fine genital setae. One pair of aggenital setae of same length and shape as genital setae. Anal plates approximately two times longer and wider than genital ones with two pairs of smooth and fine anal setae. Pore iad in adanal position. Three pairs of smooth adanal setae, setae ad_{1-2} in postanal position, three times longer than setae ad_3.

Legs. Tridactylous with median claw shorter and stronger than lateral ones. Leg setal formula I 0-3-2(1)-4(2)-19(2)-3, II 0-5-3(1)-4(1)-15(2)-3, III 2-3-1(1)-3(1)-14-3, IV 1-2-2-3(1)-12-3.

Remarks. The closest species to this new species is *P. lydiae* Jacot, 1923, described from China, but this species has the rostrum rounded without a beak-like rostral projection (Jacot 1923).

Etymology. The new species was named of honour of my friend Robert K. Headland (Cambridge, UK), renowned authority on the history of investigations and botany of the northern and southern polar regions and Australia.

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I thank Dr V. Behan-Pelletier (Ottawa, Canada), Dr A. Wells (Canberra, Australia) and Dr J. Rusek (České Budějovice, Czech Republic) for critical reading of the manuscript, two anonymous referees for constructive comments as well as to Dr. A. Wells for oribatid material from Northern Territory, Australia.

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THE WATER MITE FAMILY ATURIDAE FROM AUSTRALIA, WITH DESCRIPTION OF SIX NEW SPECIES (ACARI: HYDRACHNELLAE).

HARRY SMIT

Emmastraat 43-a, 1814 DM Alkmaar,
The Netherlands.

ABSTRACT

Four new species of the genus *Axonopsella*, *A. bidentata* sp. nov., *A. inflata* sp. nov., *A. pilbara* sp. nov. and *A. sigmoidea* sp. nov., one new species of the genus *Albia*, *A. rubicunda* sp. nov., and one new species of the genus *Austraturus*, *A. longisetus* sp. nov. are described from Northern Territory and Western Australia. *Albia rectifrons* Viets, *Austraturus longipalpis* Cook and *Twarntaturus australicus* Cook are recorded from Western Australia for the first time.

KEYWORDS: Water mites, new species, Northern Territory, Western Australia, Australia.

INTRODUCTION

The family Aturidae is represented in Australia by 13 genera (Cook 1986; Harvey 1990): *Frontipodopsis* Walter, *Tasmanaxona* Cook, *Wheenyella* Cook, *Axonopsella* Cook, *Albia* Thon, *Austraturus* Viets, *Spinaturus* Cook, *Cabellaturus* Cook, *Melenaturus* Cook, *Azugaturus* Cook, *Twarntaturus* Cook, *Barwontius* Viets and *Wheenyoides* Harvey. The most species-rich genera in Australia are *Axonopsella* (27 species) and *Austraturus* (10 species).

Only one species of the family, *Wheenyoides cooki* Harvey, has been previously recorded from the Northern Territory and Western Australia (Harvey 1990).

In the present study, four new species of *Axonopsella*, one of *Albia* and one of *Austraturus*, are described. Further, new records of *Albia rectifrons* Viets, *Austraturus longipalpis* Cook and *Twarntaturus australicus* Cook are reported.

MATERIAL AND METHODS

All material was collected by the author. Western Australia and Northern Territory holotypes and most paratypes have been deposited in the Western Australian Museum (Perth) (WAM) and in the Museum and Art Gallery of the Northern Territory (Darwin) (NTM). Additional paratypes and all referred material have been deposited in the Zoological Museum of the University of Amsterdam (ZMA).

The following abbreviations are used: Cx II - second coxal plates; Cx 4 - coxoglandularia 4; PII - second segment of palp; IV-leg-4 - fourth segment of fourth leg. Measurements are in µm. Measurements of paratypes are given in brackets.

SYSTEMATICS

Axonopsella Lundblad, 1930

Axonopsella Lundblad, 1930: 54.

In most cases it is impossible to recognize females of this genus. Females are therefore not always illustrated. The assignment of the females is based on association with the males with which they were collected. As stated by Cook (1986), palps are not very variable in the Australian *Axonopsella* species and are therefore not illustrated for most species. The separate antenniform platelet is only visible in an anterolateral view, as it is located just ventral of the anterior margin of the dorsal shield, and is therefore not illustrated.

Axonopsella bidentata sp. nov.
(Fig. 1A-D)

Type material. HOLOTYPE - NTM A95, ♂, Radon Springs, Kakadu National Park, Northern Territory, Australia, 19 July 1994.

Diagnosis. Fourth pair of acetabula pointed and extending well beyond posterior body margin. Ventral margin of heavy seta of IV-leg-4 with two teeth.

Description. *Male*. Dorsal and ventral shield present. Body 300 long and 235 wide; body colour lilac. Antenniform setae on separate platelet. Ventral shield with rounded posterolateral extension. Suture line of Cx I/II complete, all other suture lines of coxal plates incomplete or absent. Ventrum without ridges posterior to insertion of fourth legs. Gonopore 36 long. Fourth coxal plates without glandularia. First pair of acetabula placed on posterior margin of fourth

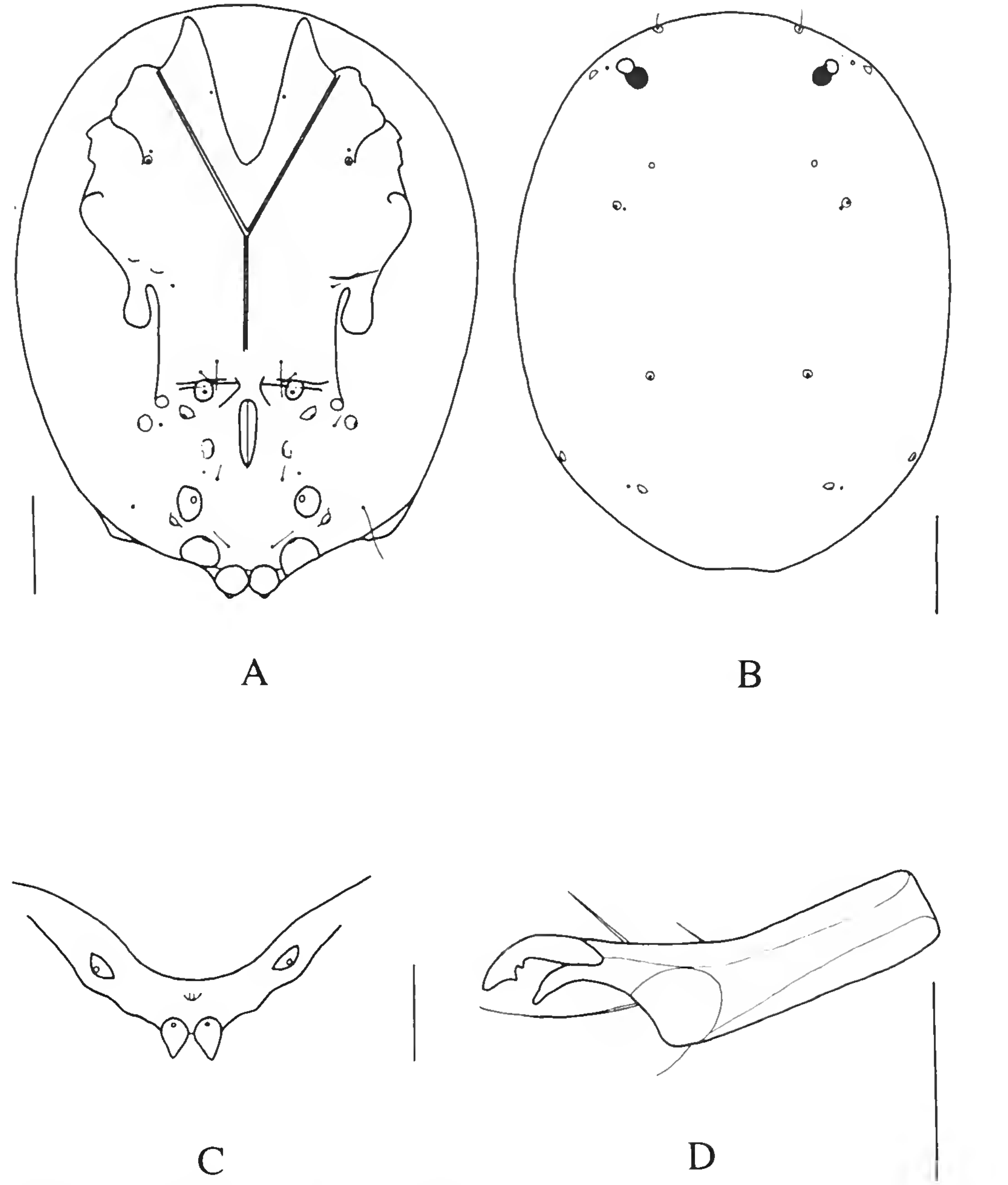

Fig. 1. *Axonopsella bidentata* sp. nov., ♂, **A**, ventral view; **B**, dorsal view; **C**, posteromedial view; **D**, IV-leg-4. Scale lines A, B, C and D: 50 µm.

coxal plates. Three pairs of acetabula located posteriorly and close together (Fig. 1A). One pair extends well beyond posterior body margin; this pair downturned and pointed. Arrangement of genital glands and genital glandularia as in Figure 1C. Dorsal lengths of PI-PV: 12, 41, 28, 54, 28; ventral margin of PII smooth. Palp normal for genus. II-leg-6 with unmodified claws. Heavy seta of IV-leg-4 relatively small, ventral margin with two teeth (Fig. 1D). Dorsal lengths of I-leg-4-6: 62, 72, 48. Dorsal lengths of IV-leg-4-6: 82, 89, 71; IV-leg-4 with three rudimentary swimming setae, one located anteriorly and two located posteriorly.

Female. Unknown.

Remarks. The shape of IV-leg-4 and the configuration of the acetabula will easily separate the new species from other species of the genus.

Etymology. Named for the two teeth on the ventral margin of the heavy setae of IV-leg-4.

Axonopsella inflata sp. nov.

(Fig. 2A-E)

Type material. HOLOTYPE - NTM A96, ♂, Lily Pond Falls, Katherine Gorge National Park, Northern Territory, Australia, 27 July 1994. PARATYPE - NTM A97, 1 ♀, same data as holotype.

Diagnosis. Large species; male II-leg-6 of triangular shape and II-leg-5 swollen.

Description. *Male.* Body 495 long and 417 wide; body colour yellowish brown. Dorsal and ventral shields present. Antenniform setae on separate platelet. All suture lines of coxal plates incomplete or absent. Cx IV with glandularia; medial suture line of Cx IV 120 long. Ventrum with ridges posteriorly of insertion of fourth legs. Gonopore large, 72 long. Genital glands flanking gonopore (Fig. 2A). Three pairs of acetabula near posterior end of body, most posterior pair located terminally (Fig. 2C). Dorsal lengths of PI-PV: 29, 84, 31, 98, 41; ventral margin of PII smooth. Dorsal lengths of I-leg-4-6: 96, 118, 77. Dorsal lengths of II-leg-4-6: 91, 173, 84. II-leg-6 very stocky (Fig. 2D), inner side almost triangular, outer side with anterior extension; II-leg-5 swollen, anterior part covered with many fine setae. Claws of second leg modified. Dorsal lengths of IV-leg 4-6: 86, 149, 118; heavy seta of IV-leg-4 large and falcated (Fig. 2E). II-leg-5 and III-leg-5 with two swimming setae, IV-leg-3 and 4 with one swimming seta.

Female. Body 616 long and 504 wide. Dorsal shield 611 long and 466 wide, posterior margin straight. Antenniform setae on separate platelet. Suture lines between Cx III/IV incomplete. Gonopore 86 wide, genital field 185 wide. Dorsal lengths of PI-PV: 30, 78, 53, 106, 43; palp as in male. Dorsal lengths of I-leg-4-6: 85, 101, 60. Dorsal lengths of IV-leg-4-6: 109, 113, 89. II-leg-5, III-leg-5 and IV-leg-5 with two swimming setae.

Remarks. This is the second largest *Axonopsella* species from Australia, only *A. magna* Cook is larger. The female of *A. magna* has a truncated posterior dorsal shield.

Etymology. Named for its swollen II-leg-5.

Axonopsella pilbara sp. nov.

(Fig. 3A-C)

Type material. HOLOTYPE - WAM 96/937, ♂, streams originating in Chinderwariner Pool, Millstream-Chichester National Park, Western Australia, 15 August 1994. PARATYPES - WAM 96/938-9, 2 ♀♀, same data as holotype; ZMA, 2 ♀♀, Fortescue Falls (pool), Hamersley Range National Park, Western Australia, 11 August 1994; NTM A98 - A103 incl., 6 ♀♀, Deep Reach Pool, Millstream-Chichester National Park, Western Australia, 15 August 1994.

Diagnosis. Ventrum of male posteriorly with three pairs of acetabula in an arc, genital gland flanking posterior end of gonopore, genital glandularia anterolateral of genital glands, well posterior to posterior suture lines of fourth coxal plates. Genital valves of female pear-shaped, narrowest anteriorly.

Description. *Male.* Dorsal and ventral shields present; body shape rounded. Body 349 long and 282 wide; body colour brownish. Antenniform setae on narrow separate platelet. Gonopore 34 long. Fourth coxal plates without glandularia. First pair of acetabula located close to posterior suture line of fourth coxal plates. Genital gland flanking posterior end of gonopore, genital glandularia anterolateral of genital glands, well posterior to posterior suture lines of fourth coxal plates. Posterior three pairs of acetabula in an arc (Fig. 3A). Dorsal lengths of PI-PV: 20, 50, 26, 65, 26; ventral margin of PII straight, anteriorly with two tiny teeth. Dorsal lengths of I-leg-4-6: 62, 62, 46. Second legs unmodified. Dorsal lengths of IV-leg-4-6: 67, 80, 67; IV-leg-4 with falcated heavy seta (Fig. 3B).

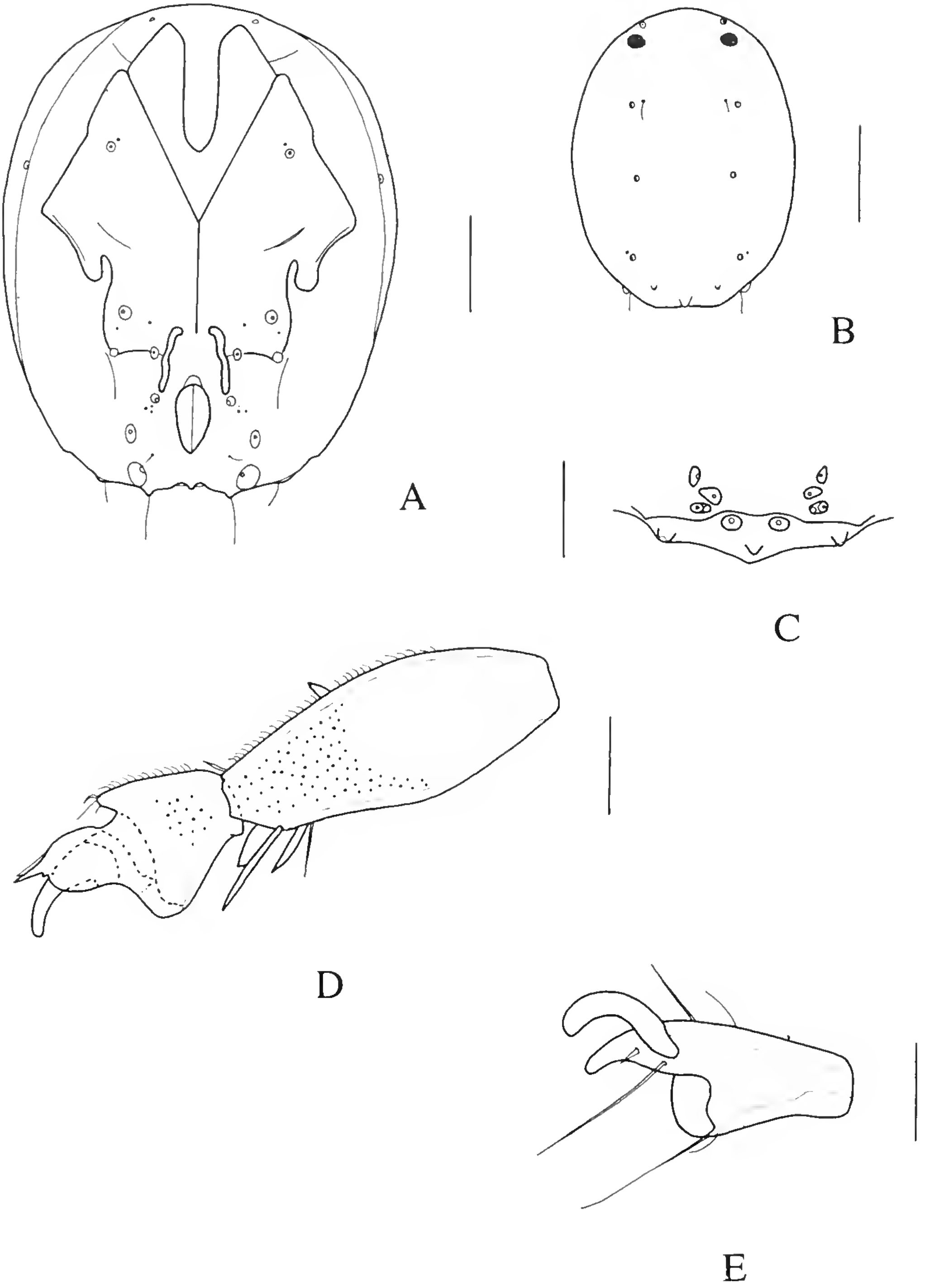

Fig. 2. *Axonopsella inflata* sp. nov., ♂, **A**, ventral view; **B**, dorsal view; **C**, posteromedial view; **D**, II-leg-4-6; **E**, IV-leg-4. Scale lines D, E: 50 µm; A, C: 100 µm; B: 200 µm.

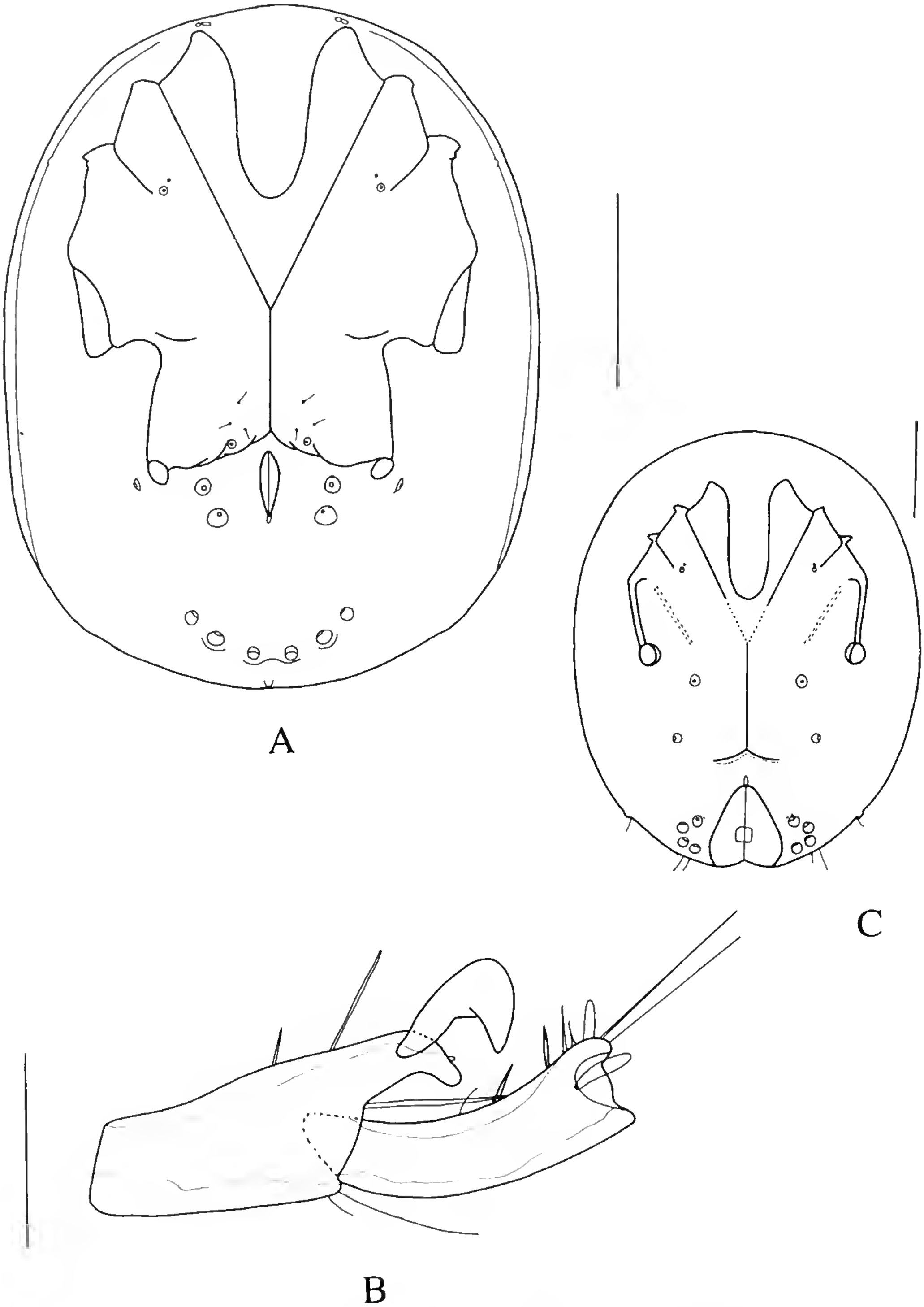

Fig. 3. *Axonopsella pilbara* sp. nov. **A**, ♂, ventral view. **B**, ♂, IV-leg-4. **C**, ♀, ventral view. Scale lines B: 50 µm; A, C: 100µm.

Female. Body 456 (407) long and 378 (325) wide. Antenniform setae on narrow separate platelet. Suture line between coxal plates incomplete. Two pairs of glandularia on fourth coxal plates widely separated. Width of genital field 194, gonopore 78 long. Genital valves pear-shaped, narrowest anteriorly (Fig. 3C). Four pairs of acetabula not in an arc, but first and fourth pair located more antero- or posteromedially. Dorsal lengths of PI-PV: 22, 66, 28, 70, 31; ventral margin of PII straight, smooth. Dorsal lengths of I-leg-4-6: 48, 65, 48; dorsal lengths of IV-leg-4-6: 79, 96, 60. III-leg-4 and IV-leg-4 with two swimming setae.

Remarks. The male of the new species is very close to *A. truza* Cook, which has the same configuration of the first acetabula, genital glands and genital glandularia. Differences between the two species can be found in the three pairs of acetabula, which form a less bowed arc in *A. pilbara*, while ridges extending posteriorly from the insertion of the fourth legs are lacking in the new species. Females of the new species are easily separable from other species by the pear-shaped genital valves.

Etymology. Named after the Pilbara Region where the specimens were collected.

Axonopsella sigmoidea sp. nov.

(Fig. 4A-E)

Type material. HOLOTYPE - NTM A104, ♂, Radon Springs, Kakadu National Park, Northern Territory, Australia, 19 July 1994. PARATYPES - ZMA, 1 ♂, plunge pool, Barramundie Creek, Kakadu National Park, Northern Territory, Australia, 24 July 1994; WAM 96/940, 1 ♂, and NTM A105, 1 ♀, small stream, Butterfly Gorge, Katherine Gorge National Park, Northern Territory, Australia, 27 July 1994.

Diagnosis. Presence and shape of modified claws of II-leg-6 and shape of IV-leg-4 (large anteroventral extension with sigmoid seta) diagnostic.

Description. *Male.* Dorsal and ventral shield present; posterior body margin concave. Body 402 long and 310 wide; body colour yellowish brown. Antenniform setae on separate platelet. All suture lines of coxal plates incomplete or absent. Ventrum with short ridges posterior of insertion of fourth legs. Pair of large glandularia located on fourth coxal plates near posterolateral corners. First pair of acetabula located slightly posterior to posterior suture line of fourth coxal plates (Fig. 4A). Three pairs of large acetabula located near posterior body margin (Fig. 4C). Genital glands flanking the gonopore. Gonopore large, 48 long. Dorsal lengths of PI-PV: 22, 52, 31, 62, 31; ventral margin of PII smooth. Dorsal lengths of I-leg-4-6: 68, 77, 62. Dorsal lengths of II-leg-4-6: 82, 120, 65; claws of II-leg-6 modified (see Fig. 4D). Dorsal lengths of IV-leg-4-6: 78, 101, 101; IV-leg-4 with large anteroventral extension, anteriorly pointed, with relative small sigmoid seta (Fig. 4E). When in different position, this seta appearing wider and less sigmoid. III-leg-5 and IV-leg-4 with one swimming seta, II-leg-5 and IV-leg-5 with two swimming setae; swimming setae of IV-leg reduced.

Female. Body 475 long and 359 wide. Dorsal and ventral shields present. Antenniform setae on separate platelet. Dorsal shield laterally with two ridges over almost its whole length. Medial margin of fourth coxal plates 108 long. Genital valves 77 wide, genital field 145 wide. Four pairs of acetabula in an arc. Dorsal lengths of PII-PV: 50, 26, 65, 34. Dorsal lengths of IV-leg-4: 79, 89, 86. II-leg-5, III-leg-5 and IV-leg-5 with two swimming setae.

Remarks. The male of the new species is easily separable from other *Axonopsella* species by the shape of IV-leg-4. Females are probably not separable from other species.

Etymology. Named for the sigmoid seta on the anteroventral extension of IV-leg-4.

Albia Thon, 1899

Albia Thon, 1899: 100.

Albia (Spinalbia) rectifrons Viets, 1935

Albia rectifrons Viets, 1935: 692.

Albia rectifrons - Uchida and Imamura 1951: 336; - Lundblad 1969: 387; - Cook 1986: 239; - Wiles 1992: 470.

Material examined. *Northern Territory.* ZMA, 1 ♀, Radon Springs, Kakadu National Park, 19 July 1994; 4 ♂♂, 22 ♀♀, billabong, Nourlangie Creek, Kakadu National Park, 20 July 1994; 1 ♀, billabong, Yellow Waters, Kakadu National Park, 21 July 1994; 15 ♂♂, 29 ♀♀, pond in Jim Jim Creek, at Jim Jim Crossing, Kakadu National Park, 22 July 1994; 3 ♂♂, 3 ♀♀, Jim Jim Billabong, at crossing with Kakadu Highway, 22 July 1994; 1 ♀, small billabong, Yellow Waters, Kakadu National Park, 22 July 1994; 1 ♀, pool near Jim Jim Falls, Kakadu

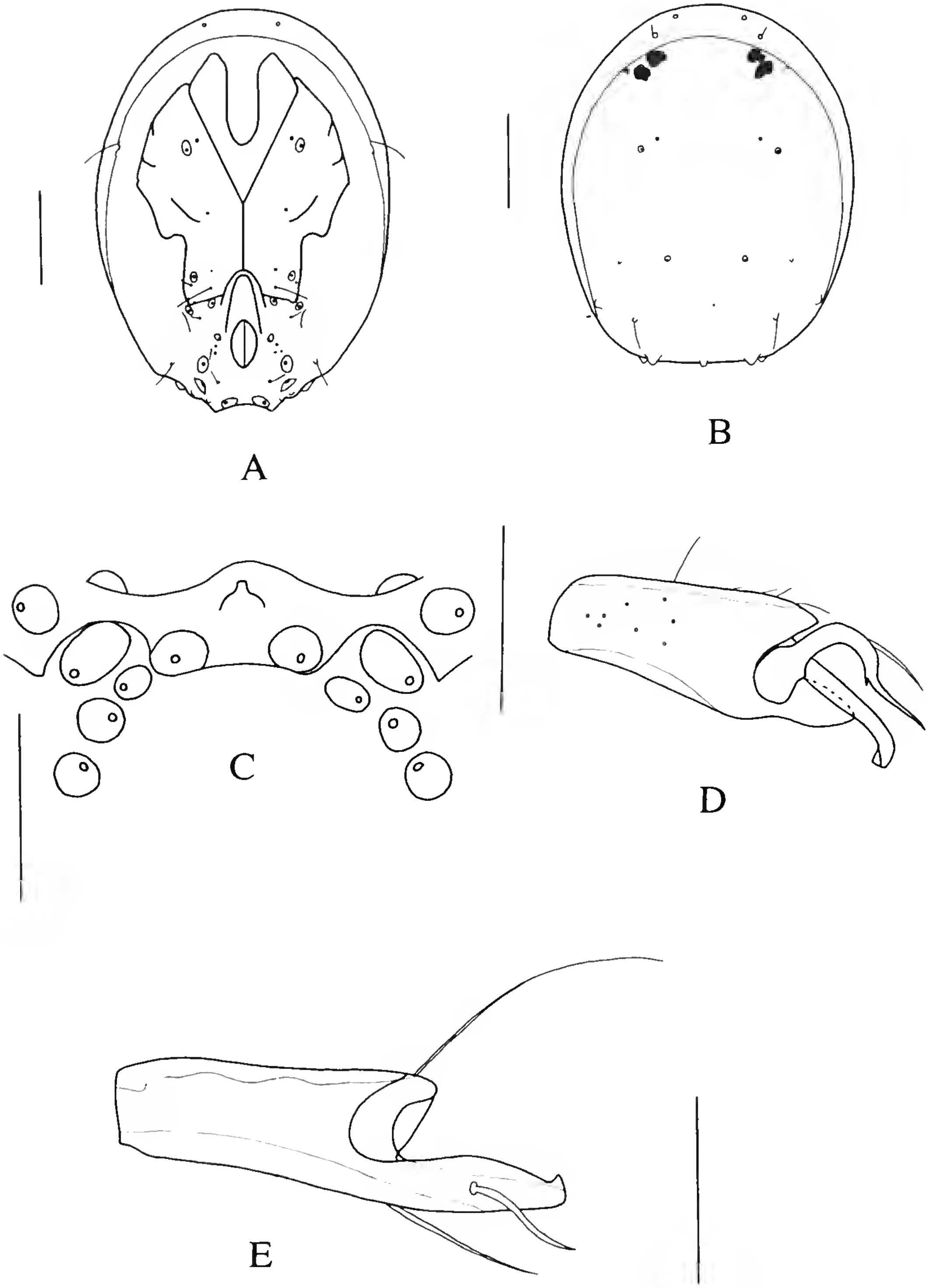

Fig. 4. *Axonopsella sigmoidea* sp. nov., ♂, **A**, ventral view; **B**, dorsal view; **C**, posteromedial view; **D**, II-leg-6; **E**, IV-leg-4. Scale lines C, D, E: 50 µm; A, B: 100 µm.

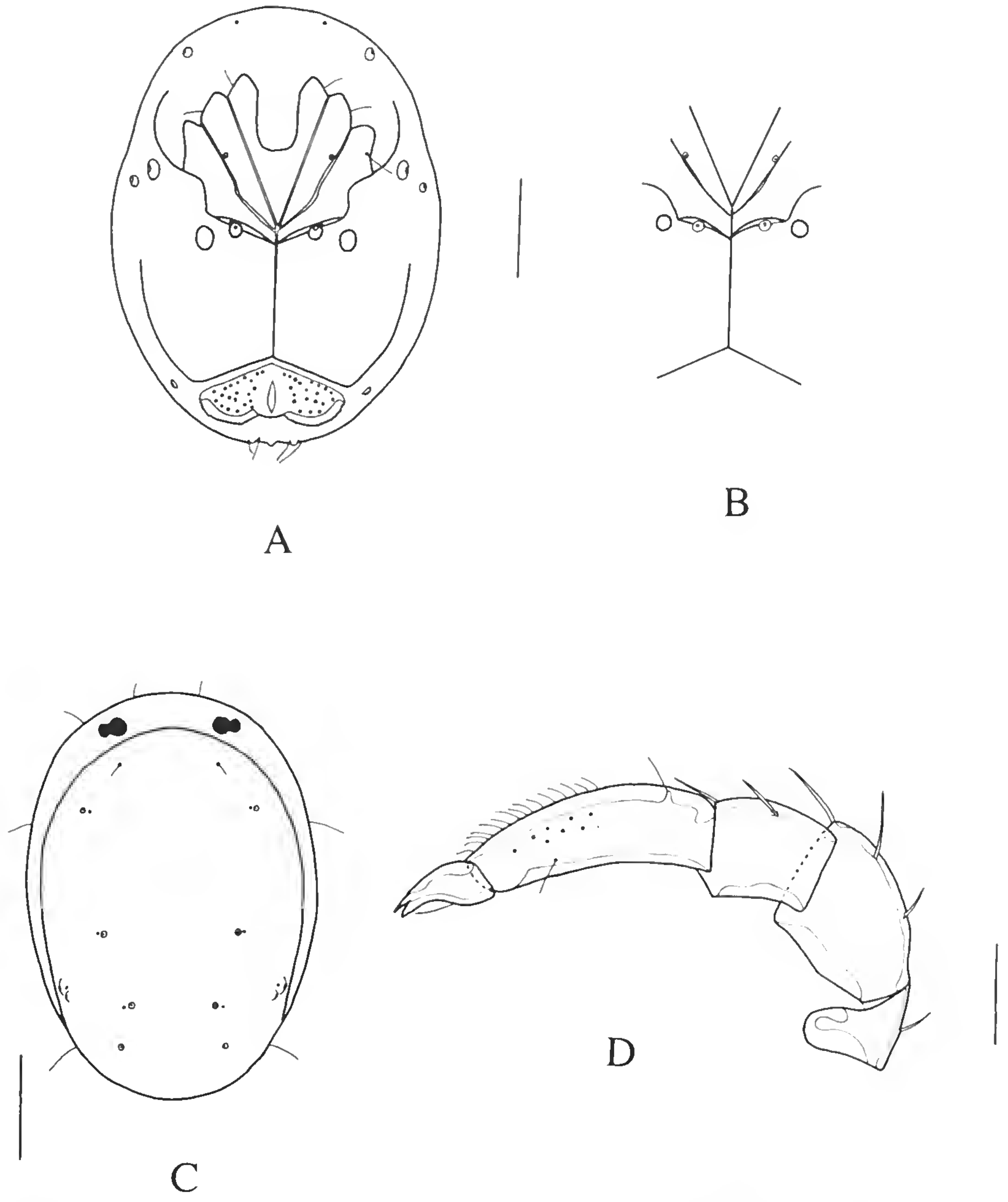

Fig. 5. *Albia rubicunda* sp. nov., ♂, A, ventral view; B, detail of suture lines paratype; C, dorsal view; D, palp. Scale lines D: 50μm; A, B, C: 200 μm.

National Park, 23 July 1994; 4 ♂♂, 6 ♀♀, pond Jim Jim Creek, near Jim Jim campground, Kakadu National Park, 23 July 1994; 2 ♀♀, pools upstream of Waterfall Creek Falls, Kakadu National Park, 25 July 1994; 3 ♂♂, 3 ♀♀, plunge pool, Gunlom Falls, Kakadu National Park, 25 July 1994; 3 ♂♂, 2 ♀♀, Lily Ponds Falls, Katherine Gorge National Park, 27 July 1994; 1 ♂, 1 ♀, plunge pool Edith Falls, Katherine Gorge National Park, 30 July 1994; 1 nymph, Douglas River, Douglas Hot Springs, 1 August 1994.

Western Australia. ZMA, 3 ♀♀, Chinderwariner pool, Millstream-Chichester National Park, 15 August 1994; 2 ♀♀, small streams originating in Chinderwariner Pool, Millstream-Chichester National Park, 15 August 1994;

1 nymph, Deep Reach Pool, Millstream-Chichester National Park, 15 August 1994; 1 ♀, small pond near Crossing Pool, Millstream-Chichester National Park, 16 August 1994; 4 ♀♀, 1 nymph, Crossing Pool, Millstream-Chichester National Park, 16 August 1994; 9 ♀♀, western part Deep Reach Pool, Millstream-Chichester National Park, 16 August 1994; 1 ♀, Fortescue River, at crossing with North West Coastal Highway, 18 August 1994.

Remarks. *Albia rectifrons* is a common and sometimes abundant species in ponds and small lakes of the Northern Territory and Western Australia.

Cook (1986) reported the species from Tasmania, Victoria, New South Wales and Queensland, all from lotic habitats. However, Wiles (1992) supposed that this was a separate species, because the Asian *A. rectifrons* lives in lentic habitats. According to Wiles the specimens described by Cook (1986) have a more rounded anterior margin. Furthermore, the length of the ventral shield to posterior of Cx IV of Asian specimens is of equal length, or shorter than, the maximum body width. Cook's specimens from Australia have the length of ventral shield longer than the maximum body width. The specimens from this study differ from the Asian populations in the body colour (yellowish in Australian specimens, olive grey/green in Asian specimens). Additionally, the specimens of this study are more slender compared to the Asian specimens, the ratio length ventral shield to posterior margin of Cx IV / width of ventral shield is 1.1-1.3 in Australian specimens, and 0.95-1.1 in Asian specimens (Wiles 1992). As in the Asian specimens, the ventral shield of the specimens of this study is truncated. I consider the differences in colour in water mites of minor importance; there are more genera which show a striking variation in colour, e.g. *Arrenurus*. Therefore, the most important difference between the Asian specimens and the specimens of this study is the body shape. However, the differences are in my opinion too small to justify a separate ranking.

Albia (Albiella) rubicunda sp. nov.
(Fig. 5A-D)

Type material. HOLOTYPE - NTM A106, ♂, Radon Springs, Kakadu National Park, Northern Territory, Australia, 19 July 1994. PARATYPES - WAM 96/941-2, 2 ♂♂; and ZMA, 2 ♂♂ and 1 nymph, same data as holotype.

Diagnosis. Suture lines of Cx I/II and Cx II/III fusing at same point at midline or posterior of Cx I/II fusing point with midline; suture line of Cx III/IV near midline not bowed; Cx 4 between leg sockets.

Description. *Male.* Dorsal shield 912 (781-847) long, width of holotype not measurable (paratypes: 563-611). Dorsoglandularia 3 close to and lateral of lateroglandularia 3. Body colour yellowish to reddish brown. Ventral shield 849 long and 645 wide; ventral shield slightly narrowed anteriorly. Coxae without spine-like setae. L 1 anterior and median to L 2. Suture line of Cx I/II, Cx II/III and Cx III/IV complete. Suture lines of Cx I/II and Cx II/III fusing at midline at same point (Fig. 5A) or posterior of fusing point of Cx I/II with midline (Fig. 5B). Cx 4 large, situated between IV-leg sockets, on suture line of Cx III/IV; suture line of Cx III/IV almost not bowed near midline. Suture line of Cx III/IV weakly indented anterior to genital field. Genital field 286 wide; gonopore 64 long. Lengths of PI-PV: 43, 84, 62, 120, 41. Lengths of I-leg-4-6: 89, 106, 103. IV-leg of holotype lost. Lengths of IV-leg-4-6 of paratype: 116, 121, 107; second, third and fourth legs with swimming setae.

Female. Unknown.

Remarks. Three species of the subgenus *Albiella* are known from Australia, i.e. *A. australica* Cook, *A. lundbladi* Cook and *A. brokenensis* Smit. The new species differs from *A. australica* and *A. brokenensis* in the almost straight suture line of Cx III/IV near the midline. Further, the genital field of the new species is much wider compared to *A. australica*. *A. lundbladi* has Cx 4 far anterior of IV-leg sockets.

Etymology. Named for its conspicuous reddish-brown colour.

Austraturus K.O. Viets, 1978

Austraturus K.O. Viets, 1978: 87.

Austraturus longisetus sp. nov.
(Fig. 6A-D)

Type material. HOLOTYPE - NTM A107, ♂, plunge pool, Edith Falls, Katherine Gorge National Park, Northern Territory, Australia, 30 July 1994.

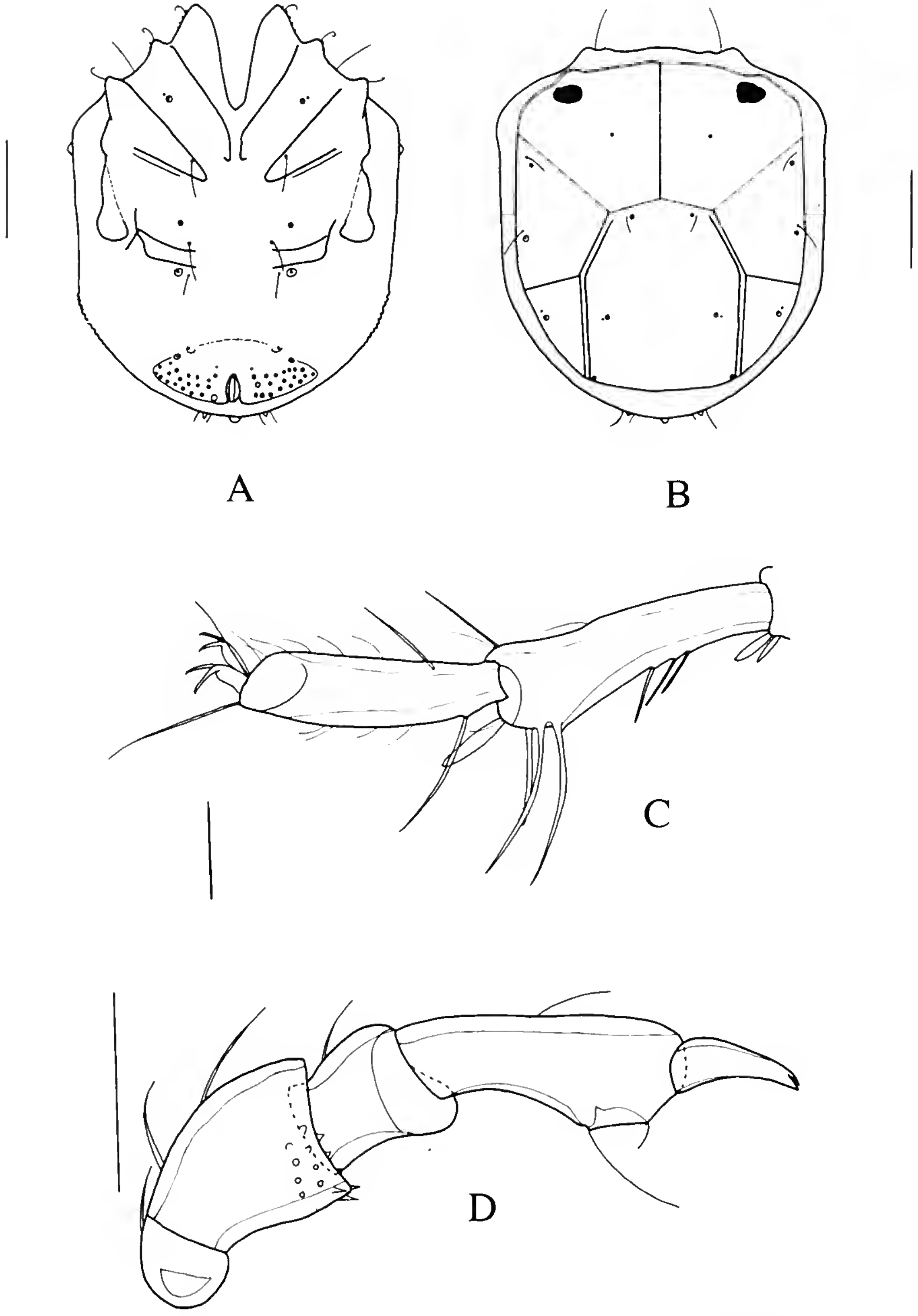

Fig. 6. *Austraturus longisetus* sp. nov., ♂, **A**, ventral view; **B**, dorsal view; **C**, IV-leg-5-6; **D**, palp. Scale lines C, D: 50 µm; A, B: 100 µm.

Diagnosis. Long setae on ventral margin of IV-leg-5 and 6 and bulge on ventral margin of PIV diagnostic.

Description. *Male*. Body 373 long and 325 wide. Dorsal and ventral shields present. Accompanying seta of glandularia of dorsal shield not thickened. Posteromedial plate of dorsum with three pairs of glandularia; this plate not modified and without concavity (Fig. 6B). Gonopore 39 long. Genital plates with numerous acetabula. Dorsal lengths of PI-PV: 31, 59, 31, 72, 34. Ventral margin of PIV with large bulge, PII anteroventrally with denticles, which extend onto lateral margin of this segment (Fig. 6D). Dorsal lengths of IV-leg-4-6: 127, 146, 115. Ventral margin of IV-leg-5 and 6 with three and two long setae respectively; long setae on IV-leg-5 whole or partially hyaline (Fig. 6C). One short hyaline seta anteroventrally on IV-leg-4 and 5; IV-leg-4 not modified.

Female. Unknown.

Remarks. Most Australian species of this genus have short setae on IV-leg-5 and 6. Only *A. tumidipalpis* Viets has two long setae anteroventrally on IV-leg-5 (three in *longisetus*) and one short seta on IV-leg-6. *Austraturus vietsi* has one long seta on IV-leg-5. All known species of the genus lack the long anteroventral seta of IV-leg-6.

Etymology. Named for the long setae on IV-leg-5 and 6.

Austraturus longipalpis Cook, 1986

Austraturus longipalpis Cook, 1986: 258.

Material examined. ZMA, 1 ♀, streams originating in Chinderwariner Pool, Millstream-Chichester National Park, Western Australia, Australia, 15 August 1994.

Remarks. Previously, this species was only known from two females collected by Cook (1986) in Queensland. The female from Western Australia has a slightly different body shape (posteriorly not truncated, first coxal plates more pointed), while the palp segments are larger. The shape of the unusual palp is similar to the Queensland specimens. Dorsal lengths of PI-PV (measurements of Cook 1986 given in brackets): 22 (19-21), 74 (67-69), 60 (48-51), 164 (138-143), 31 (33-34).

Twarntaturus Cook, 1986

Twarntaturus Cook, 1986: 266.

Twarntaturus australicus Cook, 1986

Twarntaturus australicus Cook, 1986: 266.

Material examined. ZMA, 1 ♂, 2 ♀♀, Barramundie Creek, Kakadu National Park, Northern Territory, Australia, 24 July 1994; 1 ♂, outlet Upper Pool, Edith Falls, Katherine Gorge National Park, Northern Territory, Australia, 30 July 1994.

Remarks. This species has previously only been reported from Queensland (Cook 1986).

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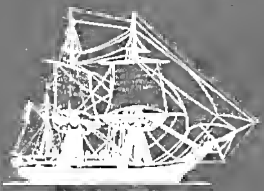

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